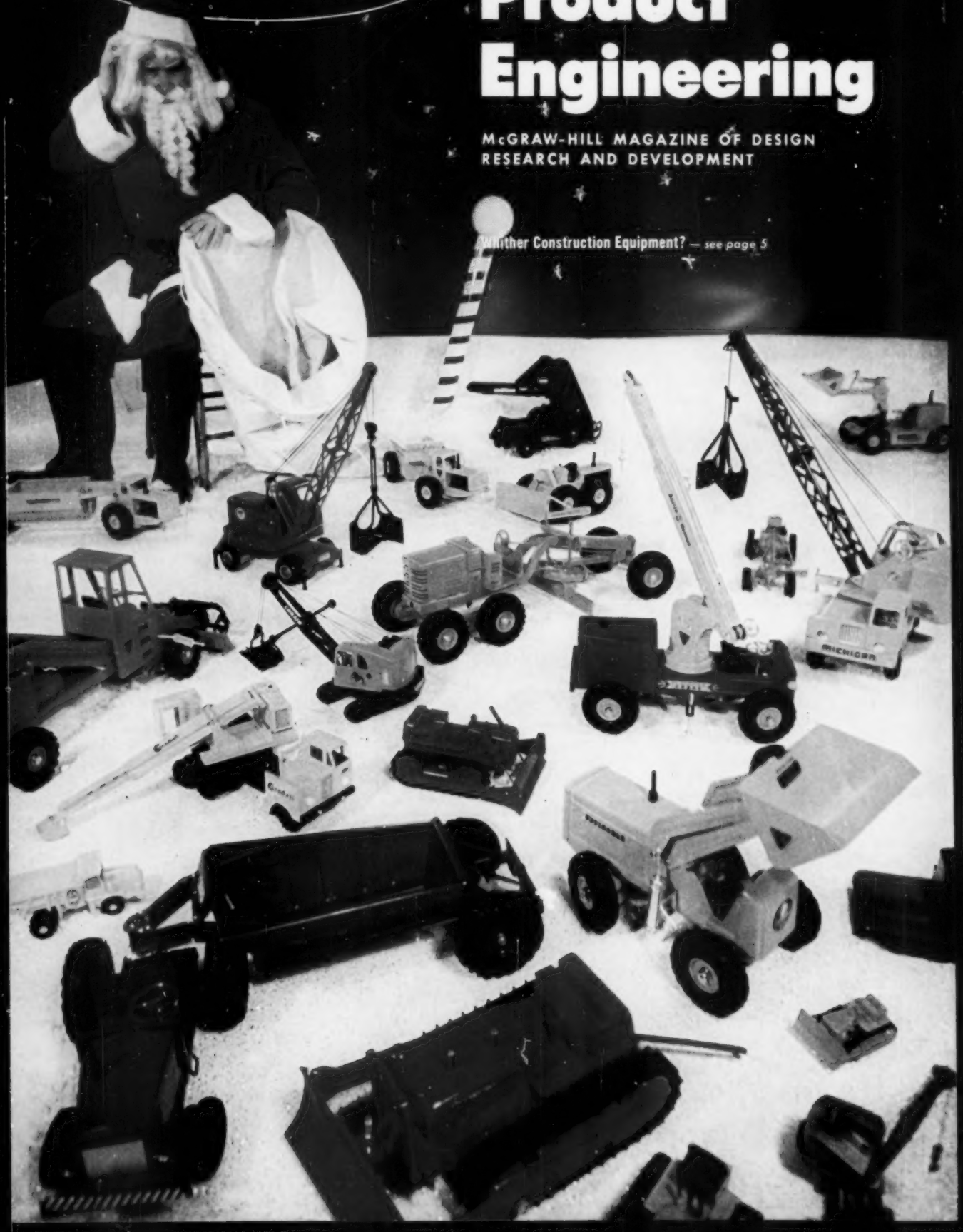
December 23, 1957 PRICE 50 CENTS

DESIGN edition

Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT



Never a shutdown to oil this Welsh Plug machine because Farval's on the job

FARVAL—
Studies in Centralized Lubrication
No. 175

THIS machine drives seven Welsh Plugs into the block of a well-known automobile engine. Uninterrupted operation is essential to its smooth performance as part of the automated line.

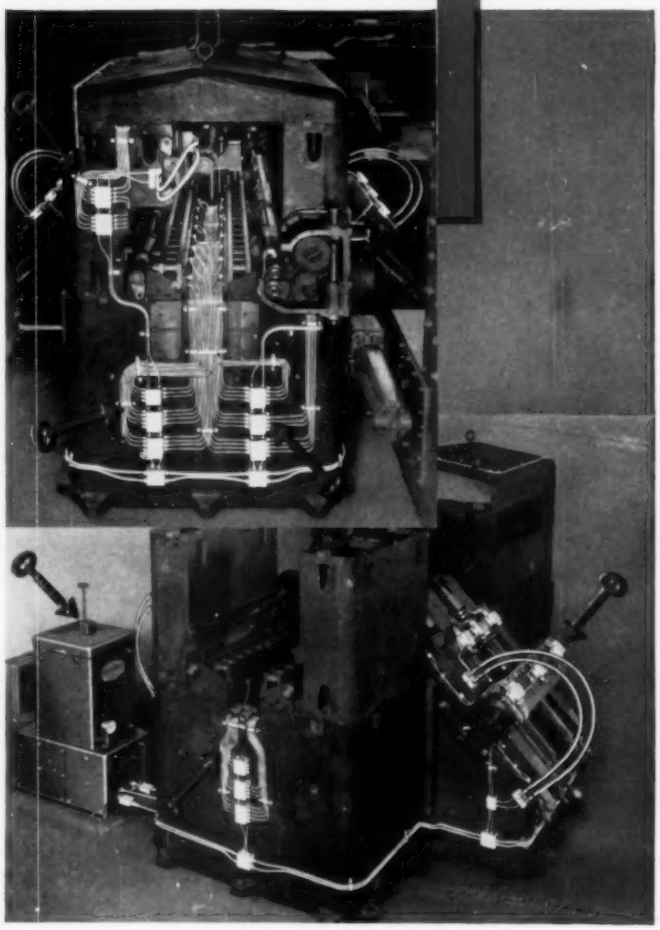
That's the reason the builder installed Farval Centralized Lubrication. These photographs were taken before final assembly of the machine, to show the extensive, orderly arrangement of Farval lubricant lines and valve manifolds serving 207 vital bearings—failure of any one of which would cripple the operation.

Now in service, the Farval system lubricates the machine automatically from the pumping station located at the left. It delivers a measured amount of oil to each bearing, as often as desired, while the machine itself is operating. Never a shutdown for lubrication! And no special oiler is needed.

Farval Automatic Lubrication is the ideal system for automation in any industry. The Farval Dualine valve placed at each bearing is simple, sure and foolproof—only two moving parts, without springs, ball-checks or pinhole ports to cause trouble. Its value proved by more than 27 years of successful service, Farval lubricates millions of industrial bearings.

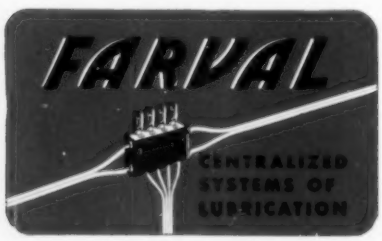
Let us send one of our lubrication engineers to analyze your plant equipment and help you determine how Farval can serve you. Just drop us a line. Ask also for Bulletin 26. The Farval Corporation, 3279 East 80th Street, Cleveland 4, Ohio.

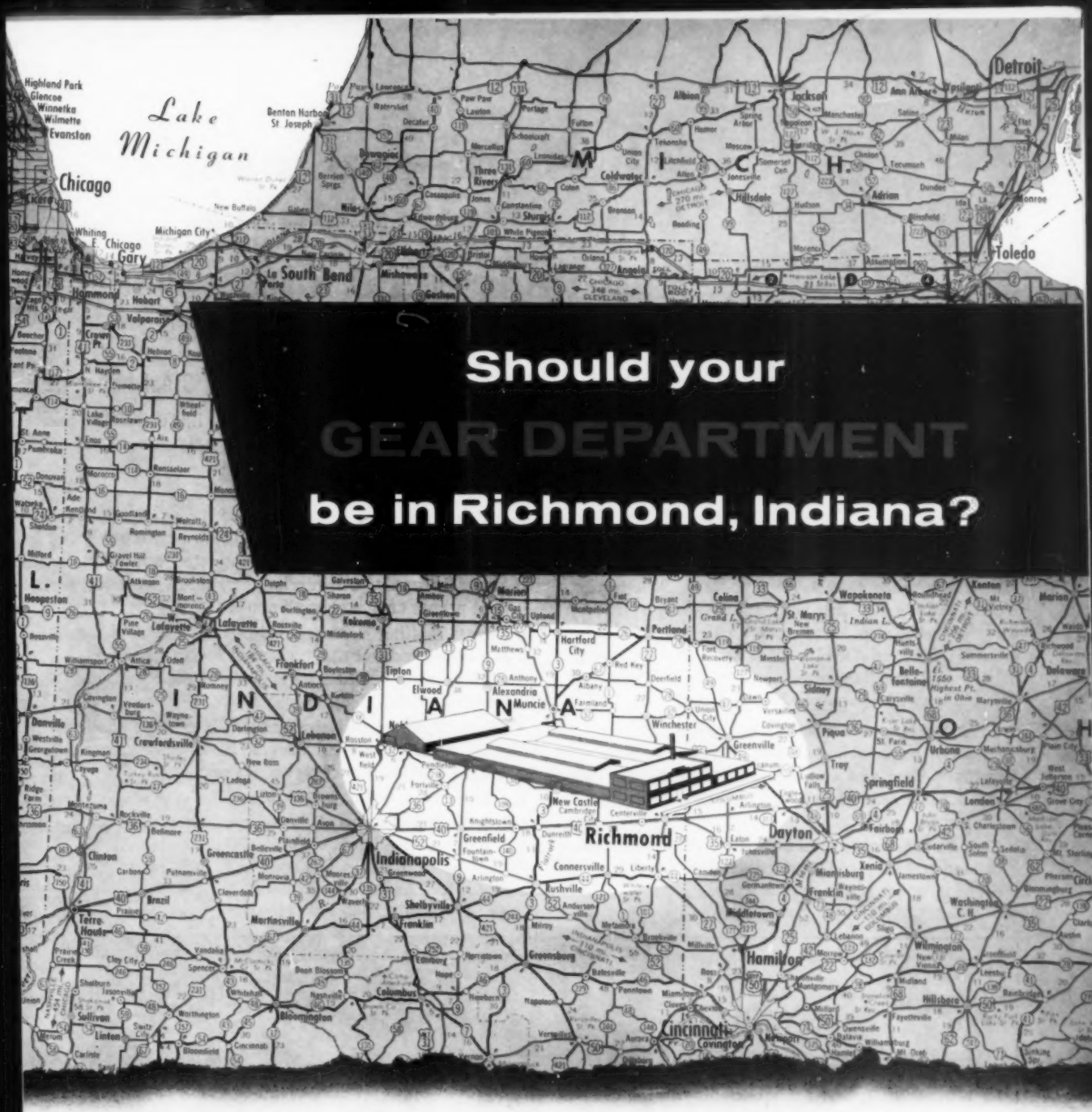
Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



KEYS TO ADEQUATE LUBRICATION—Wherever you see the sign of Farval—the familiar central pumping station, dual lubricant lines and valve manifolds—you know a machine is being properly lubricated.

These photographs of a Welsh Plug Assembly Machine, showing Farval lines and valves on both sides, by courtesy of the builder, Sainte Claire Tool Company, Detroit, Michigan.





Should your GEAR DEPARTMENT be in Richmond, Indiana?

This possibility is worth your consideration. Many of our best customers use us in this manner—as their *gear department*—with all of our facilities geared to their gear needs. Would you like to learn how successful these associations have been, and what a similar service might mean to you in terms of reduced costs and better gears?

Our Sales people are gear engineers. Would you like to talk to one? Write us at Richmond, Indiana—gear headquarters for many of America's leading industries.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Special Armco Steel Cuts Painting Costs,

Makes Your Products Look Better Longer

Mill-Bonderized Armco Cold-Rolled PAINTGRIP® Steel helps streamline painting schedules, produces smoother, more durable paint finish.

If you use painted sheet metal in your products, you'll be interested in the cost-cutting and sales-boosting advantages offered by Armco Cold-Rolled PAINTGRIP. Both service records and exposure tests prove its superiority over ordinary cold-rolled steel for parts that must be painted. The reason is this special steel is given an electrolytic "flash" of zinc and then Bonderized at the mill. It is designed specifically to take paint and hold it longer.

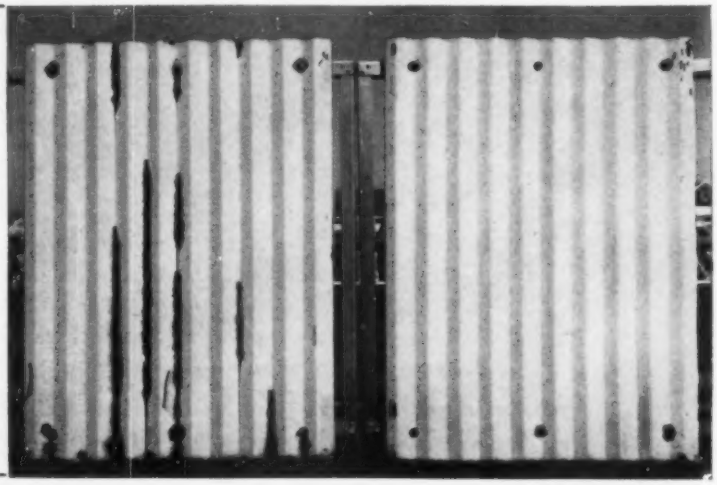
Combination of Advantages

The special paint-holding surface of Armco Cold-Rolled PAINTGRIP offers you a combination of advantages that make possible easier fabrication and improved product performance.

- **Easy to Fabricate—Can be readily formed, drawn, welded and soldered. Surface remains intact during drawing or forming.**
- **Simplifies Painting—Cold-Rolled PAINTGRIP is ready to paint. Surface treatment eliminated and paint easier to apply. On interior unexposed surfaces, mist-primer coat may be eliminated.**
- **Resists Rusting in Storage—Not recommended for use unpainted but can be stored inside as sheets, coils or semi-finished parts without rusting. Cuts cleaning costs.**
- **Longer Paint Life—Helps assure uniformly smooth paint finish that lasts several times longer than paint on untreated cold-rolled steel.**

Consider Armco Cold-Rolled PAINTGRIP for *your* products. Its many advantages may help you cut finishing costs and add new customer-appeal. This paint-preserving Armco Steel is produced in sheets and coils in 12 to 28 gage. Write us today for complete information.

Results of two years in an industrial atmosphere. Same paint schedule for both panels. Scratched to accelerate flaking. Left—Untreated Cold-rolled steel. Right—Armco Cold-Rolled PAINTGRIP.



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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

DECEMBER 23, 1957 **Vol. 28, No. 25**

When Splines Need Stress Control— 56... D. W. Dudley, General Electric Co.
This article gives charts and formulas for computing four important types of stresses that must not be exceeded if a design is to work successfully.

New Aluminum Forging Alloy— 62... Warren Bomhardt, The Martin Company
Lower notch sensitivity makes alloy 7079 better than the older 7075 for thick sections requiring high strength. This run-down covers its limitations too

How to Communicate— 64... J. O. Dibbs and R. F. Philip
Snafu galore results when a message doesn't get across. In a two-section article, the authors tell best ways to give instructions, prepare a report.

Vacuum Coatings Go Industrial— 67... P. J. Clough, National Research Corp.
Once limited to decorative uses, these metal films are finding many industrial applications, such as in the corrosion-resistance and miniaturization fields.

Design Features in New Products— 70...
Tractor becomes power package; portable electrocardiograph; riveter moves along work; grippers control moving paper.

Linkages Gain on Cams— 75... A staff report
New graphical design method developed in Germany for four-bar linkages is replacing complex mathematical analysis previously required.

New Nylon from France— 76... J. Fouqué, Organico, Paris
An introduction to nylon-11, now available in the US and rated superior to established nylons in water absorption, ease of plasticizing, thermal resistance.

STAFF REPORT

Design for Pay Dirt— 80...
Bulldozers, cranes, power shovels are impressive, but what about the components needed to make them bigger and better? We asked the questions—and here are the answers from leading builders of earth-moving equipment.

DESIGN FILE

How to Lubricate Ways— 92... W. O. Wright, Bijur Lubricating Corp.
Nine examples of small dovetail guides, angled and circular ways.

Torque of Slip Couplings— 95...
Formulas and charts for force, torque and friction-conversion factors.

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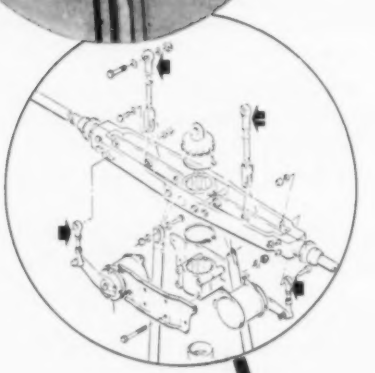
THE NEW "BELL RANGER" HELICOPTER USES HEIM UNIBAL ROD ENDS

Model 47-J is the latest helicopter to be introduced to the commercial market by Bell Helicopter Corp., and has been named the Bell Ranger. It is a four-place, executive type machine with a deluxe interior or a series of quick-change cabin arrangements for cargo, litter, and internal hoist configurations.

HEIM Unibal Rod Ends were chosen for the linkages in the carburetor heat and mixture control installations, and in the main rotor stabilizer bar assembly. The rods link hydraulic dampers to the bar, which provides exceptional stability to the flight characteristics of Bell helicopters, acting like a gyroscope and, through mixing levers, keeps the rotor plane of rotation in its pre-established flight path.



THE HEIM *Unibal* is the spherical bearing which corrects misalignment in every direction because of the universal movement of the ball — Reduces friction and lost motion in linkages — Eliminates the effects of vibration — Lowers assembly costs because of its quick and easy installation — Carries heavier loads.

Perhaps Heim can help solve — or simplify — your linkage problems. Feel free to write. Be sure each engineering and purchasing department has a Heim catalog.

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Pettibone-Mulliken Speed Swing 180° Swing Loader
Le Tourneau-Westinghouse Tournahopper Model 1500
Le Tourneau-Westinghouse Tournarocker Tournatractor Model 1300 Dozer Model 1900
Unit #357 Mobile Crane
Caterpillar Diesel #12 Motor Grader
Adams Motor Grader
Michigan T-24 Excavator Crane
Adams Traveloader Model 1800
Lorain Crawler Shovel
Austin-Western Telescoping Crane
Warner & Swasey Gradall Machine
Allis-Chalmers Diesel Tractor
Hough Payloader
Euclid Rear Dump Truck
Euclid Model 2009 Bottom-dump Truck
Barber-Greene #879 Asphalt Finisher
Caterpillar Bulldozer
International Harvester TD-24 Crawler Tractor with Blade
Lorain Mato-Crane
Caterpillar D-6 Bulldozer

A Constructive Christmas

Back during the depression, a senator objected eloquently to the fact that one government contractor was digging a ditch by machine. "A hundred men with shovels are being denied a living by that thing!" he thundered.

"Or a thousand men with teaspoons," retorted the contractor—and went on with his digging.

Our cover shows how far we have come from shovels in construction equipment. It was planned initially as a successor to the cover picturing aircraft models (Oct. 28) and to tie in with the survey of trends in construction-machinery design in this issue, p. 80. Most of these models not only work, they are also very sturdy toys. Hence the introduction of our bewildered Santa Claus and the conversion into a Christmas Card.

The models were sent in to us by the companies who make

(Continued on page 7)

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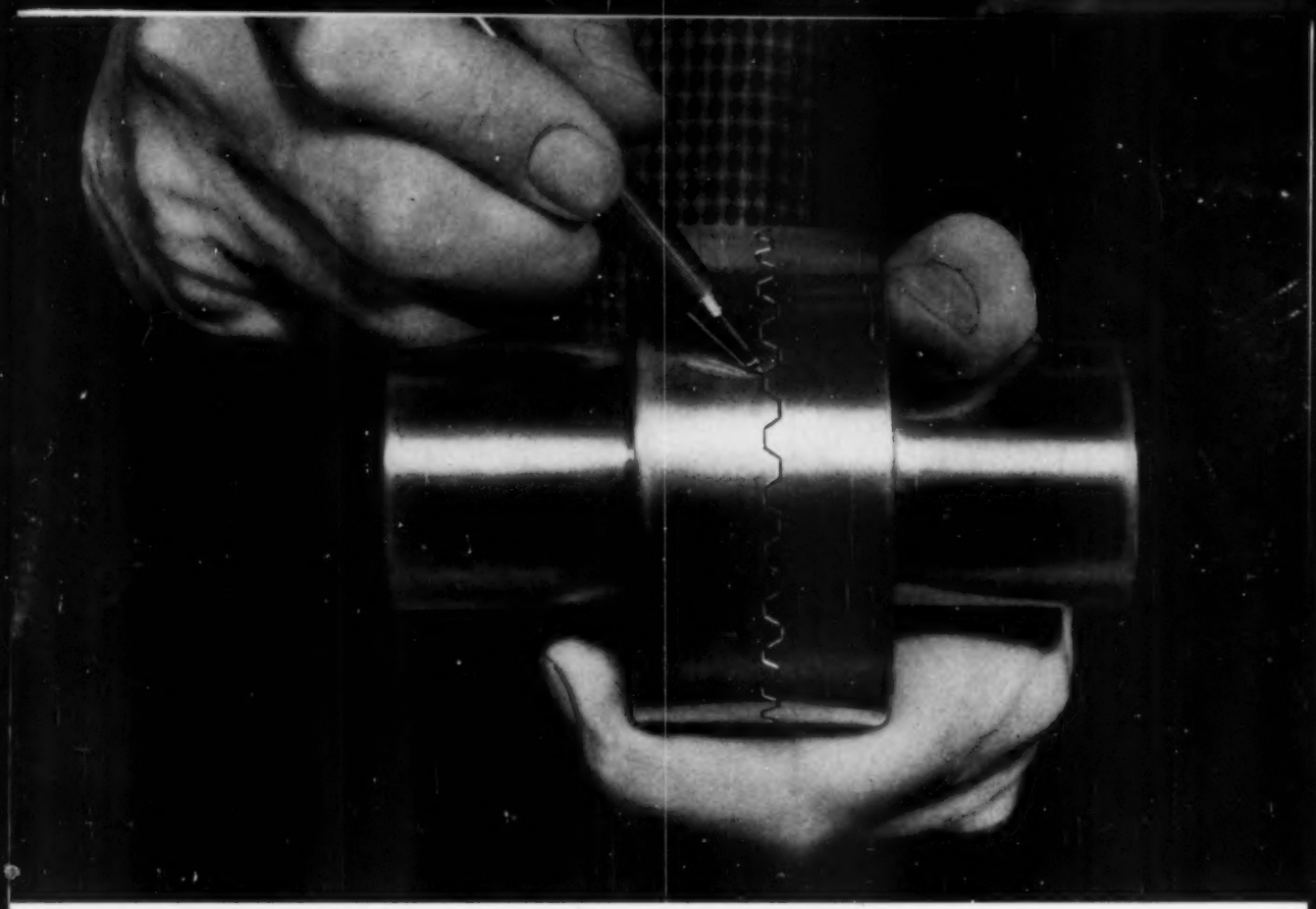


This photograph shows tooth contact of a Curvic Coupling used in an aircraft drive shaft. The coupling simplifies the manufacture and assembly of this shaft and permits "in the field" maintenance.

CURVIC® COUPLINGS—*what they are and how they can help improve your product*

Curvic Couplings are precise face splines that drive, center and align parts with a high degree of accuracy.

They can improve your product by giving improved design, simplify maintenance through the use of interchangeable parts and lower production costs by eliminating the need for large complex parts.

Because Curvic Coupling teeth curve lengthwise—either concave or convex—contact between the joining teeth is controlled. The load carried is equally distributed on all teeth as tooth-to-tooth spacing is held to extremely close limits. Therefore, Curvic Couplings can be made smaller, thinner and lighter than many other types of toothed connections.

Three principal types

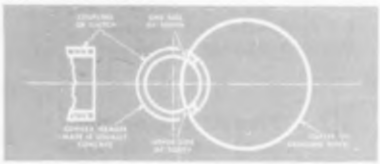
1. *The permanent Curvic Coupling* is used for driving *and* aligning. It is for such uses as building up accurately balanced, precision rotors for jet aircraft engines. Curvic Couplings can hold mating parts within 0.0005" total runout.

2. *The semi-universal Curvic Coupling* allows misalignment of shafts (2° maximum) together with axial freedom. Localized tooth bearing prevents load concentration on ends of teeth.

3. *Shift and overload Curvic Clutches* maintain proper tooth contact while the clutch engages and disengages. Shift clutches are used in washing machine wringer drives, motor trucks, outboard motors, aircraft —wherever a positive toothed clutch is needed.

Overload clutches are used where the amount of torque to be transmitted must be regulated, as in power screwdrivers.

The Gleason Engineering Department will be glad to consult with you regarding Curvic Couplings for your product. Write for our booklet.



The drawing above shows the method of producing both sides of Curvic Coupling teeth with the same surface of the cutter or grinding wheel, so that both sides have the same curvature. Curving the teeth lengthwise in this manner assures control of contact between joining teeth.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

the full-sized equipment, but most are the products of toy-makers who use the trademarks by agreement. Exceptions are the Gradall (a true model), the two Lorain shovels (both desk models) the pavement finisher (desk model), the Caterpillar machines (made up of die castings), and the IH tractor (plastics). The others are sheet steel, produced by Ny-Lint, or Model, and sell in toy stores at from $5.95 to $17.95, depending on complexity. (Some of ours have been returned, the rest are making orphan youngsters happy this Christmas.)

McGraw-Hill Studio made quite an elaborate picture-taking setup in this case. A wide-angle lens was essential to get necessary depth of focus—the layout is only about 3 ft wide in front, and about 10 ft at the back, with blue "sky" covering one entire studio wall. The "snow" is white paper with aluminum-impregnated sparkle. Santa is our own associate editor, Hank Cook, dressed in a velvet-and-fur costume complete with genuine yak-hair wig, all borrowed from the local undertaker. He sweltered in the glare of at least a dozen flood and spot lights. In any case, the cover brings you holiday greetings from the editors, and the hope for a good year in 1958, from all the staff of *Product Engineering*.

Breaking the Language Barrier

When the United Nations first began the task of listening to delegates speaking in their native langauges, it immediately faced the necessity of having an accurate translation come through simultaneously with the original. The challenge was met. Today, a delegate can dial in on his headphones any one of the five major languages: English, French, Spanish, Russian and Chinese.

During one crucial debate soon after the UN's inception, an interpreter's mistake almost became an international issue. The delegate from France was speaking. In French, he requested the US delegation to stand behind his resolution. The appropriate French verb form for "ask" or "request" is "*demande*." In haste, the interpreter made the mistake every student of the language has made at one time. Instead of: "The French delegation requests the United States . . ." it came out ". . . demands that the United States . . ." You can imagine the commotion that ensued. It was several hours before the error was recognized and tempers soothed.

Communication is one of the most important problems in the world, and this certainly is true in the area of product design. Two aspects of the problem—from viewpoint of the manager and engineer—are discussed on page 64.

A Slick Discovery

At the British Institute of Mechanical Engineers in 1882, young scientist Beauchamp Tower was conducting friction experiments on journal bearings. To test the effect of lubricating with an oiler, Tower drilled a hole through the bearing bronze. No sooner had the oiler been removed, when oil poured from the newly drilled hole. He stopped the flow with a wooden plug, but it was soon forced out. Tower realized immediately that a fluid pressure existed, and verified his belief with a pressure gage.

He followed up this accidental discovery with pressure experiments at various points in the fluid film. Integrated over the area of the bearing, the pressure readings were in close agreement with the measurement of the load being carried. This demonstrated the nature of hydrodynamic lubrication. Film lubrication of this sort is seen in lubricated ways (see page 92).

Tower didn't fully realize the importance of his work until Osborne Reynolds put Tower's findings into mathematical form in his classic hydrodynamic theory of lubrication. This paper has been called "the turning point in the history of oil-film lubrication."

The Day Lisbon Was Razed

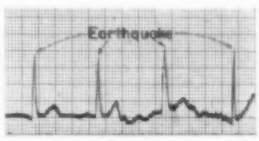
All was quiet in Lisbon at 9:29 am on that Saturday, Nov. 1, 1755. It was All Saints' Day and many of the city's 275,000 people were attending morning masses in one or another of the churches and cathedrals. In the streets were fishmongers and shopkeepers selling their wares. Twenty monks had made the pilgrimage from Spain to the Convento de Santa Truindade, one of Portugal's most beautiful churches. Lisbon was at peace.

At 9:30 those at worship felt a slight rumble and attributed it to heavy traffic out in the streets. But those outside saw no traffic—and were afraid. After a brief pause came 120 seconds of Hell. Roofs tumbled, walls cracked and fell, the facades of churches, palaces, houses and shops were licked by the tongue of destruction. The third tremor completed the horror. What had been day was night; what had been Lisbon was ruin.

More than 15,000 were killed instantly. Who can estimate the loss of life and property that fed the fires following the quake? Those who tried to hide were crushed or burned. Those who tried to flee by sea were swallowed by tidal waves. There was no escape.

Earthquakes can neither be controlled nor predicted. If they could, San Francisco could have been saved in 1906, Tokyo and Yokahama could have evacuated the 100,000 people who died in 1923. The seismograph can detect a tremor and nothing more.

It is interesting that another instrument has also detected earthquakes. Last spring, Dr. J. F. Sadusk, Jr. of Oakland Calif., reported picking up a tremor on his Electrocardiograph. After examining the heart of a patient, he noticed four large irregularities on his graph. Upon checking, he found he had recorded the tremors of a local quake. In the field of electrocardiography is a new lightweight portable unit, pictured on page 73. The heart of a patient can now be more easily studied. Will we ever understand the heart of the earth.

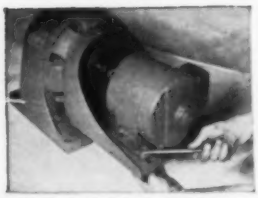


BENEDICT A. LEERBURGER JR.

EFFICIENT NEW RUNNING MATE

for latest NEMA motor sizes . . .

LINK-BELT Motogear designed for bracket-mounting foot-type motors of any manufacturer



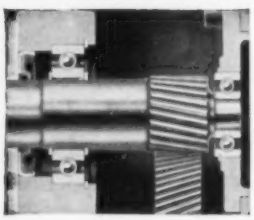
EASY MOTOR REPLACEMENT—Remove four mounting bolts and separate coupling. Oil drainage is unnecessary. Sturdy bracket design aids motor re-alignment.

ABILITY TO ACCOMMODATE A WIDE RANGE OF MOTORS meets emergencies, minimizes downtime.

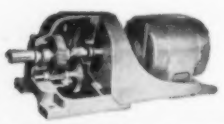
Immediately available from stocks near you—new Link-Belt Motogears in sizes up to 60 hp, output speeds from 280 down to 6 rpm.

Wherever space is restricted . . . where downtime means a costly break in production continuity—Link-Belt Motogears soon pay their own way. In addition to easy motor replacement—simplified ratio changes and quick accessibility of parts for maintenance offer major service savings.

Contact your nearby Link-Belt office or authorized stock-carrying distributor for facts. Ask, too, about the new flange-mounted Gearmotors stocked in sizes up to 30 hp. Or write for Book 2447, giving details of both.



RIGIDITY of high-speed shaft and pinion is provided by straddle-mounting — extremely important in coping with shock, reversing or heavy loads.



ONE LOW-SPEED GEAR SET per drive size and maximum accessibility of all operating parts simplify inspection, maintenance and ratio changes.

LINK-BELT

ENCLOSED DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.310

Developments To Watch

FURTHER DESIGN CHANGES IN MACHINE TOOLS . . .

. . . are indicated by recent progress in alumina ceramics. Norton Company's newest ceramic cutting tool tips, for instance, are made with oxide particles "about a third as fine as face powder," have a microstructure that gives them far greater toughness, so cutting speeds can be stepped up from 100 fpm to 200 fpm or more on such hard-to-cut materials as chilled cast iron.

But, says Norton, to take full advantage of these cutting tips more power, rigidity and speed will be required.

A LOT MORE ALUMINUM IN CARS . . .

. . . is forecast by M. F. Garwood, Chrysler Corp.'s chief materials engineer. Noting that Chrysler is already the largest consumer of aluminum in the auto industry (100 lb per car), he expects at least a 50% increase in the next 10 years.

Among the newer aluminum parts at Chrysler are impact-extruded spark plug tubes which, as Garwood points out, make it possible to eliminate multiple-die forming operations and costly electroplating.

Now under test are aluminum radiators; die-cast aluminum engine blocks and heads; extruded and cast aluminum bumpers, which may be provided with inserts of stainless steel or vinyl plastic to protect them from denting.

CASTOR OIL FOR PLASTICS? . . .

. . . Yes, say Allied Chemical and DuPont. They find that rigid and semirigid castor oil-polyurethane foams come closer than any materials so far tested to meeting the requirements for a low-rebound, low-density material for crash padding. But the two companies note that the new foams are not likely to replace any now on the market for general-purpose use. Low rebound is not always desirable, and castor oil foams do not promise any particular price advantage.

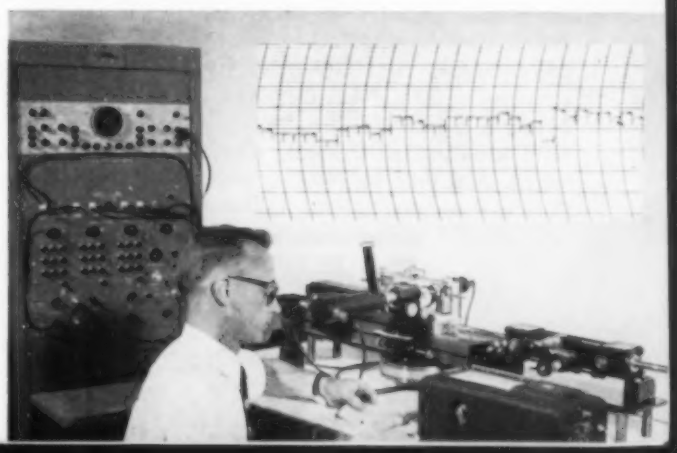
VARIATIONS IN PITCH UNIFORMITY . . .

. . . of screw threads, grids and other periodic structures are measured automatically at Bell Telephone Laboratories, using a new instrument called a "microdeviometer." It combines two optical gratings (one fixed and one movable) that act as a distance scale, an optical position-measuring device, and an electronic analyzer-recorder.

The part to be evaluated is mounted on a moving platform which also contains one of the gratings. This moves past the fixed grating, interrupting a beam of light trained on a photocell when the rulings on the two are superimposed, and producing electrical impulses proportional to distance increments of one micron.

Meanwhile, another light beam and another photocell are arranged to produce an output pulse whenever an element of the structure passes a fixed reference point.

The two pulses are then fed to an electronic computer which evaluates the deviation from the ideal form and records it on a chart. —ARG



Pitch is measured . . . by instrument that puts evaluation of periodic structures on automatic basis, provides permanent record for future study. Mechanical-optical section is in center, computer at left; section of chart is inset.

Vibration won't loosen FLEXLOC self-locking nuts

Where products must be reliable . . . must stand up under vibration, temperature extremes and hard use . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting locking action. And they are reusable: repeated removal and replacement, frequent adjustments, even rough screw threads will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes, types and materials to meet the most critical locknut requirements. Your local industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

We also manufacture precision titanium fasteners. Write for free booklet.

FLEXLOC® LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

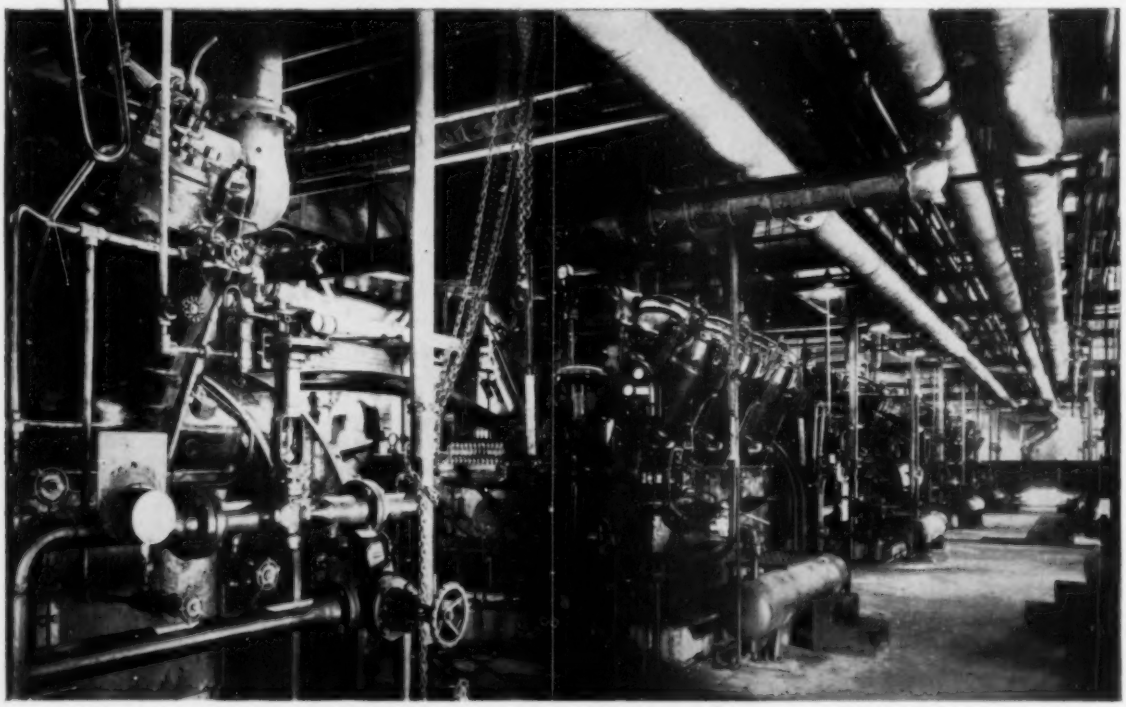
NEW ZINC I.D. TUBING RESISTS CORROSION— RETAINS OUTSTANDING STRENGTH, DUCTILITY AND *ECONOMY* OF STEEL!

You can now use economical steel tubing for applications formerly restricted to more expensive materials. Through an exclusive and inexpensive process, GM Steel Tubing makes available tubing that withstands corrosion and yet retains the important strength and economy of steel.

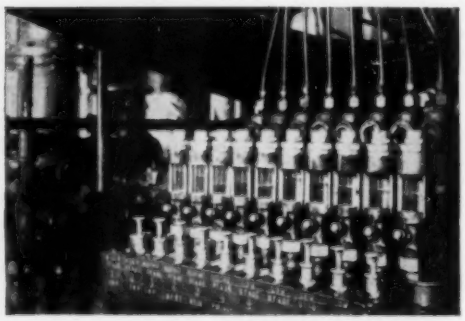
Outstanding new GM Steel Tubing with Zinc I.D. has a corrosion-resistant metallic coating which is non-porous, uniform in thickness and sufficiently ductile for manufacturing operations. The coating does not yield a volume build-up of corrosion deposits. The tubing is completely annealed and the coating entirely intact when delivered. Investigate the immediate savings possible with GM Steel Tubing with Zinc I.D. Write direct or call your GM Sales Engineer. And watch for important tubing advances of the future to take shape at GM Steel Tubing.

GM STEEL TUBING by ROCHESTER PRODUCTS

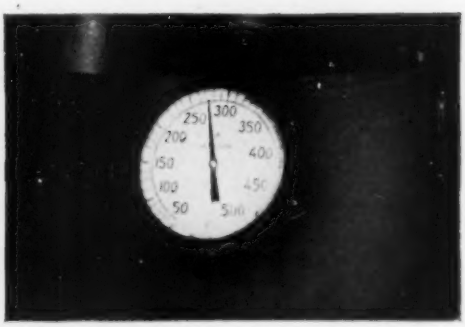
ROCHESTER PRODUCTS DIVISION OF GENERAL MOTORS, ROCHESTER, N. Y.



"... Cellulubes were tested for two years in four Cooper Bessemer Air Compressors. Cylinder wear was negligible. Deposits normally found in compressor auxiliaries and valves were reduced or eliminated."



"... A conventional lubricator will pump Cellulubes satisfactorily. No obnoxious vapors—does not present a personnel problem in terms of handling a toxic material."



"... No pressure surges nor evidence of fire in the air accumulator when Cellulubes are used. They are excellent lubricants, and also are effective as detergents."

CELANESE CORPORATION OF AMERICA, CHEMICAL DIVISION
DEPT. 547-L 180 MADISON AVENUE, NEW YORK 16, N. Y.

Please send me:

☐ Technical bulletin ☐ Sample of_____viscosity.

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Application I have in mind_____

From a trial file covering two years testing in Cooper Bessemer 3-stage air compressors

"NO PRESSURE SURGES...NO EVIDENCE OF FIRE... EXCELLENT LUBRICATION...WHEN FIRE-RESISTANT CELANESE CELLULUBES ARE USED!"

"Cellulube has now been in four of our Cooper Bessemer air compressors for approximately two years. The compressors were inspected during a recent Catalytic Reformer General Inspection. Cylinder liner wear was negligible, particularly when compared to the amount of wear we had experienced when previously using a synthetic lubricant. Cellulube, in addition to acting as a lubricant, is also effective as a detergent. Compressor cylinder air passages which had been heavily coated with carbonaceous materials and deposits laid down by the previous synthetic lubricant, are gradually being removed and the compressors again show the original factory finish. Deposits on valve cages and plates have been reduced and are no longer a problem.

"Cellulube does not present a personnel problem in terms of handling a toxic material. There are no obnoxious vapors from Cellulube. A conventional lubricator will pump Cellulube satisfactorily.

"There have been no pressure surges nor evidence of fire in the air accumulator.

"We believe this material is an excellent lubricant plus the fact that acting as a detergent the deposits normally found in compressor auxiliaries and valves have been reduced or eliminated."

These results are typical of what you can expect from Celanese Cellulubes. They have been developed to meet the pressing need for fire-resistant lubricants which virtually eliminate the problem of carbon deposits.

Celanese Cellulubes are available in 6 controlled viscosities: 90, 150, 220, 300, 550, 1000, S.U.S. @ 100°F. These straight phosphate esters provide excellent lubricity, are non-corrosive and non-reactive.

Celanese Cellulubes open new areas for in-plant protection against fire and explosion. Evaluate them in your own operation. Use coupon to request samples and technical data.

Celanese®
Cellulube®

Celanese
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Celanese Corporation of America, Chemical Division, 180 Madison Avenue, New York 16, N.Y.
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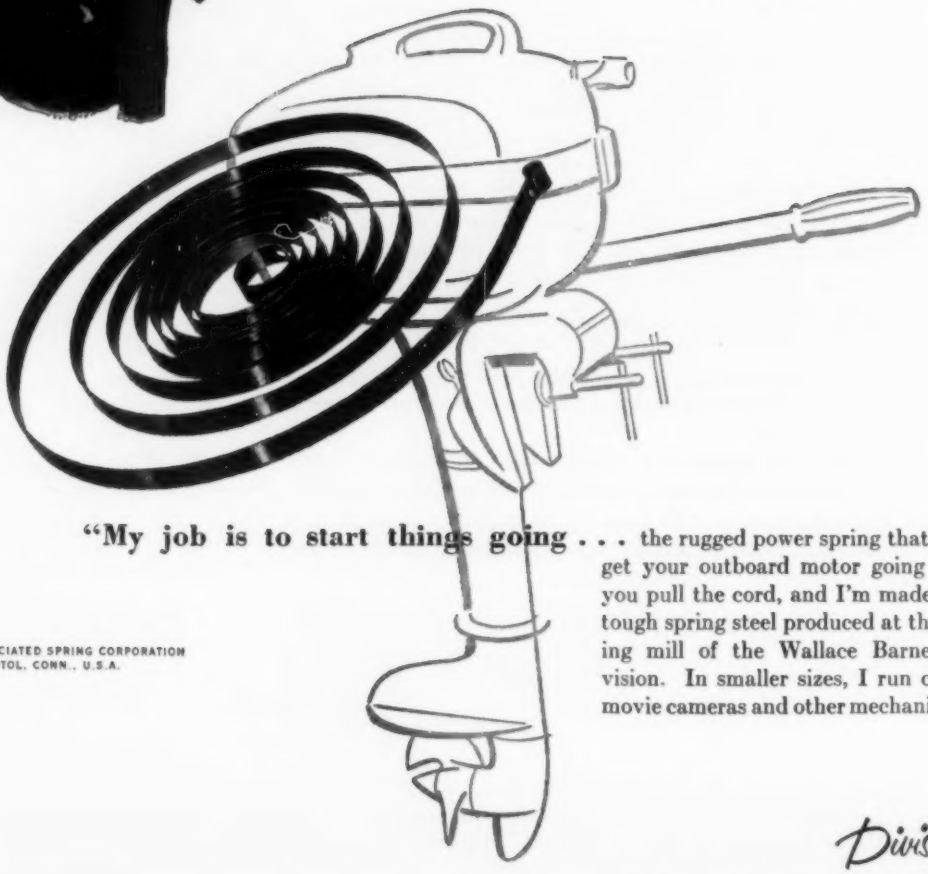
CELANESE CELLULUBES

Interviews...

"I'm a life-giving spring . . .

. . . just an ordinary-looking coiled spring, made of stainless steel, I perform my work in blood transfusion apparatus—always dependable—like every A.S.C. spring."



"My job is to start things going . . . the rugged power spring that helps get your outboard motor going when you pull the cord, and I'm made from tough spring steel produced at the rolling mill of the Wallace Barnes Division. In smaller sizes, I run clocks, movie cameras and other mechanisms."

5730

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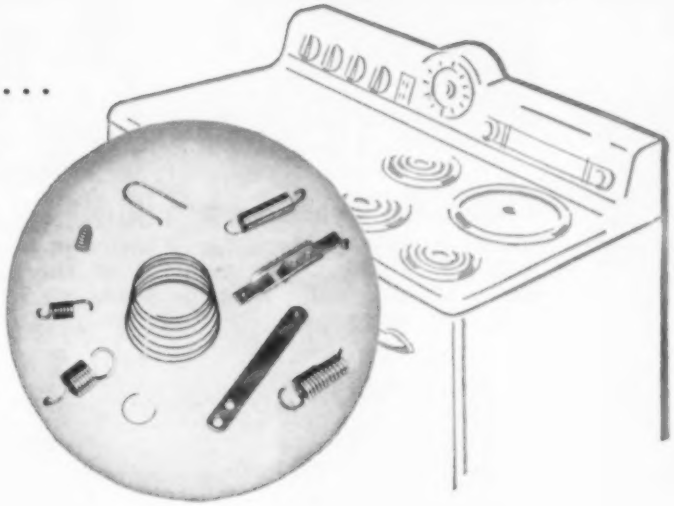
BRISTOL, CONN., U.S.A.

Divisions of

with Successful Springs

**"We'll time your eggs . . .
or turn off the current . . .**

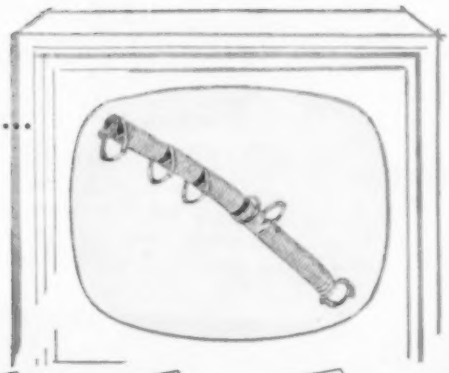
. . . we're the family of coil and flat springs that control the timing of your electric stove, dishwasher, clothes washer and dryer. Divisions of A.S.C. make all types of instrument springs."



"Call me up sometime . . .

. . . and when your finger dials a Division of Associated Spring Corporation, I'm the spring that returns the dial after each number selection—always at your service."

"Tune me in on T V. . . .



. . . I'm not really a spring—but A.S.C. engineers figured how to make tuning coils like me with special coatings on a spring winder. *If you need a spring—or a thing that looks like a spring—see a Division of Associated Spring Corporation."*

Send for Pamphlet "Designing Springs for Performance"

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RAYMOND Manufacturing COMPANY, CORRY, PENNSYLVANIA

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B-G-R COOK PLANT, ANN ARBOR, MICHIGAN

SEABOARD Pacific Div., 15001 S. BROADWAY, GARDENA, CALIF.

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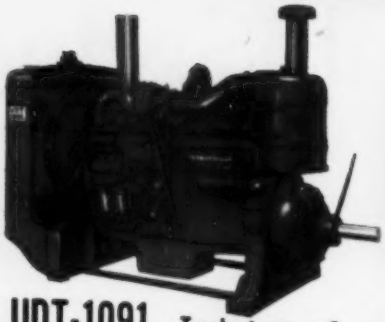
ASSOCIATED SPRING CORPORATION

GENERAL OFFICES: BRISTOL, CONNECTICUT

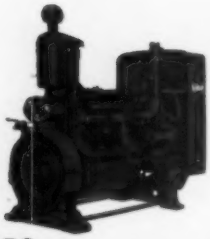


UDT-1091 Turbotorque® Diesel 6-cyl; 5¾ x 7; 1,091 cu. in. displ.; Eng. hp @ 1500 rpm: Max. 300; int. 265; Power Unit Int. load hp —250 @ 1500 rpm

UD-1091 6-cyl Diesel 5¾ x 7; 1,091 cu. in. displ.; Eng. Max. hp—224 @ 1500 rpm; Power Unit Int. load hp—202 @ 1500 rpm

UD-18A 6-cyl Diesel 4¾ x 6½; 691 cu. in. displ.; Eng. Max. hp—150 @ 1600 rpm; Power Unit Int. load hp —125 @ 1600 rpm

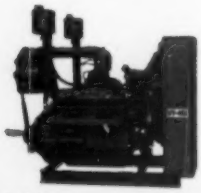
U-501 6-cyl Carbureted 4½ x 5¼; 501 cu. in. displ.; Basic Eng. Max. hp: Gaso.—212 @ 3000 rpm; Power Unit Net hp: Gaso. — 133 @ 2200 rpm; LPG—128 @ 2200 rpm



U-450 6-cyl Carbureted 4⅜ x 5; 450 cu. in. displ.; Basic Eng. Max. hp — Gaso. — 182 @ 3000 rpm; Power Unit Net hp: Gaso. — 126 @ 2200 rpm; LPG—124 @ 2200 rpm

U-372 6-cyl Carbureted 4⅜ x 4⅛; 372 cu. in. displ.; Basic Eng. Max. hp—Gaso.—165 @ 3200 rpm; Power Unit Net hp: Gaso. — 104 @ 2200 rpm; LPG—97 @ 2200 rpm

UV-549 V-8-cyl Carbureted 4½ x 4¾; 549 cu. in. displ.; Eng. Max. hp: Gaso. — 257 @ 3400 rpm; Power Unit Net hp: Gaso. — 208 @ 2600 rpm; LPG—201 @ 2600 rpm

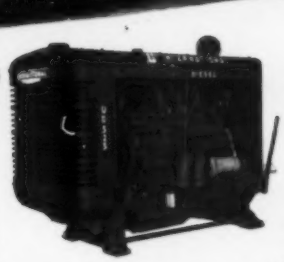


UV-461 V-8-cyl Carbureted 4⅛ x 4¾; 461 cu. in. displ.; Eng. Max. hp: Gaso. — 226 @ 3600 rpm; Power Unit Net hp: Gaso. — 169 @ 2600 rpm; LPG—169 @ 2600 rpm

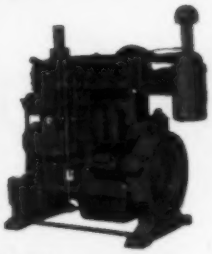
UV-401 V-8-cyl Carbureted 4⅛ x 3¾; 401 cu. in. displ.; Eng. Max. hp—Gaso.—206 @ 3600 rpm; Power Unit Net hp: Gaso. — 155 @ 2800 rpm; LPG—155 @ 2800 rpm

Power that protects your reputation as a specifier!

Call in THE MAN FROM INTERNATIONAL for the full story on 20 heavy-duty industrial engines that deliver a full measure of dependable power

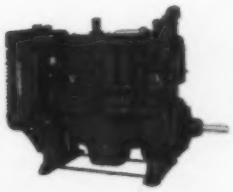


UD-525 6-cyl Diesel
4½ x 5½; 525 cu. in. displ.; Eng. Max. hp—137 @ 2000 rpm; Power Unit Int. load hp—115 @ 1800 rpm



UD-14A 4-cyl Diesel
4¾ x 6½; 461 cu. in. displ.; Eng. Max. hp—105 @ 1800 rpm; Power Unit Int. load hp—76 @ 1400 rpm

UD-350 4-cyl Diesel
4½ x 5½; 350 cu. in. displ.; Eng. Max. hp—92 @ 2000 rpm; Power Unit Int. load hp—75 @ 1800 rpm



UD-281 4-cyl Diesel
4⅛ x 5¼; 281 cu. in. displ.; Eng. Max. hp—68 @ 1800 rpm; Power Unit Int. load hp —60 @ 1800 rpm

U-308 6-cyl Carbureted 3¹³⁄₁₆ x 4½; 308 cu. in. displ.; Basic Eng. Max. hp—Gaso.—154 @ 3600 rpm; Power Unit Net hp: Gaso.—87.5 @ 2400 rpm; LPG —91.2 @ 2400 rpm

U-264-6 6-cyl Carbureted 3¹⁵⁄₁₆ x 4⅛; 264 cu. in. displ.; Basic Eng. Max. hp — Gaso. 153 @ 3700 rpm; Power Unit Net hp: Gaso. — 78 @ 2400 rpm; LPG—81 @ 2400 rpm

U-220 6-cyl Carbureted 3⅛ x 3¹⁵⁄₁₆; 220 cu. in. displ.; Basic Eng. Max. hp: Gaso. — 112 @ 3700 rpm; Power Unit Net hp: Gaso.—68 @ 2400 rpm; LPG—68 @ 2400 rpm

U-281 4-cyl Carbureted
4⅛ x 5¼; 281 cu. in. displ.; Power Unit Net hp: Gaso. — 67.5 @ 1800 rpm; LPG—73 @ 1800 rpm

U-175 4-cyl Carbureted
3⅜ x 4¼; 175 cu. in. displ.; Power Unit Net hp: Gaso. — 50 @ 2000 rpm; LPG—51.5 @ 2000 rpm

U-123 4-cyl Carbureted
3⅛ x 4; 123 cu. in. displ.; Power Unit Net hp: Gaso.—33 @ 2000 rpm; LPG—27.5 @ 2000 rpm

UC-60 4-cyl Carbureted
2⅝ x 2¾; 60 cu. in. displ.; Power Unit Net hp: Gaso.—16.5 @ 2500 rpm; Nat. gas —13.5 @ 2500 rpm

Here you see the complete expanded 20-model line of International power—heavy-duty engines and power units that continue to justify the judgment of men who have specified International for more than 50 years.

Choose any of the 13 carbureted industrial engines, from 16 to 257 hp, or seven diesels, from 60 to 265 intermittent load hp, with full confidence. You'll always get an engine that delivers a full measure of dependable, economical power. And every engine is backed by the finest parts and service support in the world.

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International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois

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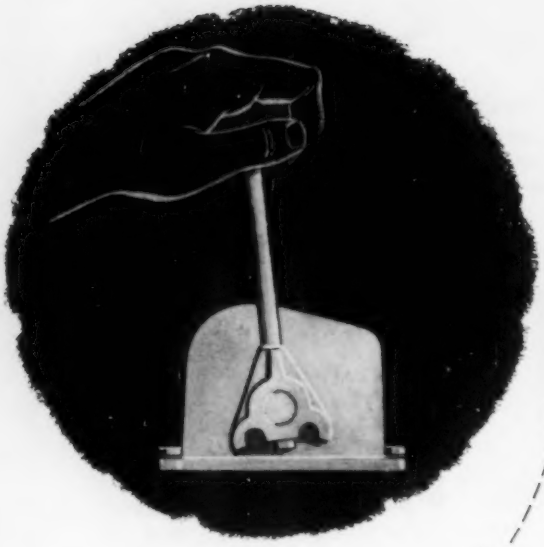

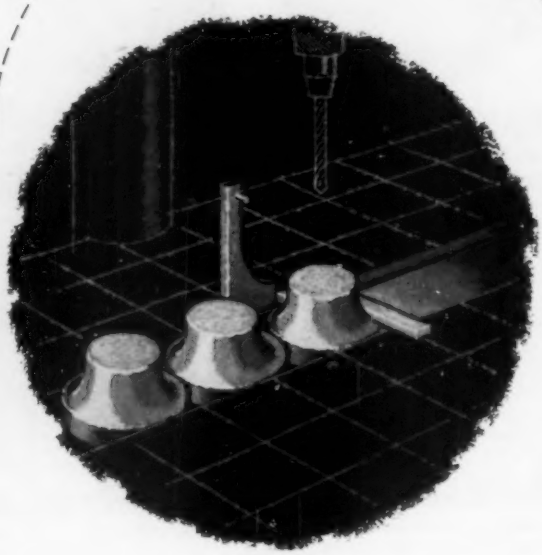

Control them all with WESTINGHOUSE

If you want to position a workpiece precisely . . . if you want to hold it securely while drilling, machining, or forming . . . if you want to move that piece quickly on its way to the next operation . . . then, take advantage of the simplicity, the economy, and the reliability of Westinghouse Pneumatic Control.

Today, Westinghouse Pneumatic Control can give you accurate remote control of modern assembly line machines or entire processes. It can give you precise interlocking and sequencing control. It also can help you to prevent human errors.

Best of all, Westinghouse specialists can help you with the application of pneumatic control to your operations. They bring you control engineering experience in a wide variety of industries—from control of assembly line manufacture to the operation of rugged earth moving equipment. You can get this helpful service throughout the world (overseas, from affiliated Westinghouse companies). Send the coupon for more information on modern uses for pneumatic control.

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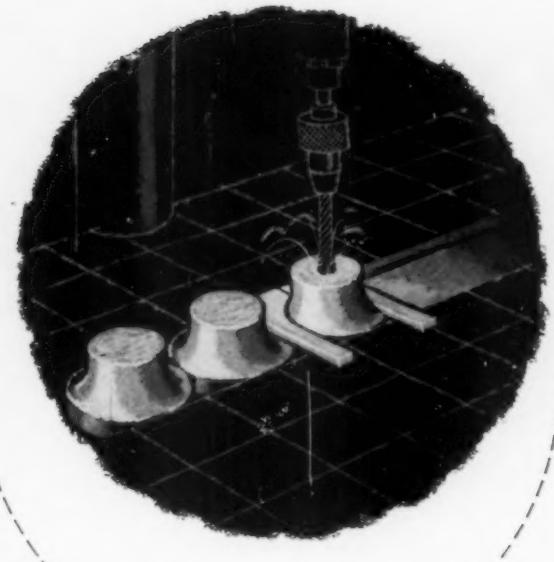
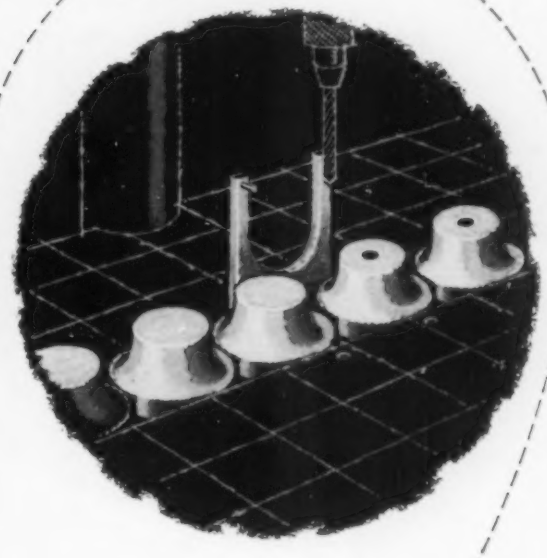


MOVE



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Confidence—the world over

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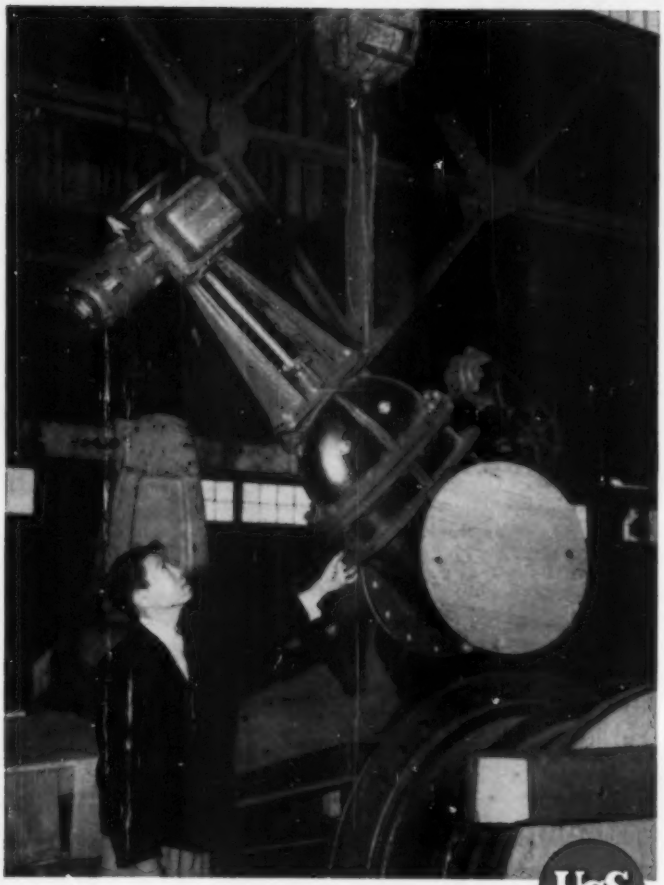
HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS:

First Major Bridge Application for "T-1" Constructional Alloy Steel—USS "T-1" Steel is being used in the construction of the $20-million Carquinez Straits Bridge, which will connect the busy San Francisco Bay area with the Sacramento Valley. Almost a duplicate of the 30-year-old existing structure it parallels, the new bridge, at left, differs most in that it is making use of 2,900 tons of USS "T-1" Steel. And those are 2,900 important tons because, according to design computations by the State of California, USS "T-1" Steel's weldability and 90,000 psi minimum yield strength will *lower* the cost of the bridge some $800,000. For example: one of the top chord members of the new bridge will weigh 400 lbs. per ft. and have a section area of 117.19 sq. in. A structural carbon steel (A-7) member for the same location would weigh 996 lbs. per ft. and would require a section of 293 sq. in.



At Home In A Crowd. That's USS "T-1" Steel. It's really at home in this, the crowd rack of the world's largest power shovel. Built by Marion Power Shovel Company, the big digger is in service for Hanna Coal Company. Operating around the clock, winter included, the crowd rack must withstand constant, brutal impact loading, often in sub-freezing temperatures. USS "T-1" Steel (also used in the dipper, dipper stick and bail) supplies the strength, toughness, and resistance to impact abuse so critically needed.

Fabri-Valve Fabricates Faster For Less. The Fabri-Valve Company of America fabricates valves as opposed to casting them. A recent job for the U.S. Air Force called for 2 types of electric-motor-operated wedge-gate valves, subject to temperatures from well below zero up to 300° F., and pressures of 37.5 psi absolute plus a shock load of 200 psig. By using USS "T-1" Steel for the majority of the valve parts, Fabri-Valve pared off 25% of the time and expense normally required to fabricate the valves. Quoting the Company's Vice President, "USS 'T-1' Steel was chosen for its toughness, impact strength, its quality of handling low temperature applications. Very important, too, is its ready weldability and fabricability. USS 'T-1' Steel's yield strength of 90,000 psi helped reduce thickness, thereby reducing cost."

HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,000 psi and its minimum tensile strength of 105,000 psi, can help you design or build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking severe impact and abuse at sub-zero temperatures. Its weldability can help you cut the cost of fabricating highly stressed parts, and reduce repair and maintenance expense. Its good creep rupture strength can help you put more durability in equipment that operates at temperatures as high as 900 degrees F.

Somewhere in your operation, versatile USS "T-1" Steel can help you. Write, wire, or phone United States Steel, Pittsburgh 30, Pa.

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

"USS" and "T-1" are registered trademarks

United States Steel Corporation, Pittsburgh • Columbia-Geneva Steel Division, San Francisco • Tennessee Coal & Iron Division, Fairfield, Ala.
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UNITED STATES STEEL

U.S. Army Redstone Missile

THE *FORWARD* LOOK

CHRYSLER CORPORATION

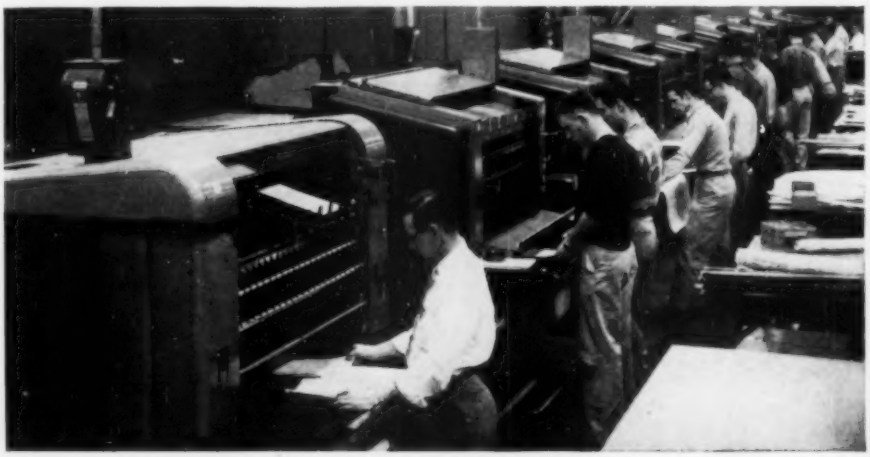
BRUNING Reproduction Machines help Chrysler Corporation in Vital Missile Work!

Most of the great work that Chrysler Corporation is doing in missiles must be classified for security reasons. It is no secret, however, that this progressive firm — creators of the advanced "forward look" in automobiles — has played a vital role in the development of the ballistic missile indicated above.

It is no secret, either, that Chrysler Corporation utilizes the outstanding advantages of modern Bruning Copyflex diazotype reproduction machines in this important work. Shown here is the imposing battery of Copyflex machines employed by the Chrysler Corporation. You can see for yourself the famous problem-free installation of Copyflex — no exhaust venting, plumbing, or auxiliary equipment. You can see, too, how Copyflex provides busy operators with such advantages as roomy feed tables, extra-large, convenient stacking trays.

And that's only part of the story. You, like Chrysler Corporation, should be benefiting by such modern Copyflex advantages as greater mechanical speeds, faster return of originals, synchronized exposure and development, automatic separation of originals from exposed prints, automatic stacking, and front-or-rear print delivery.

If you're not getting these important advantages, then every day you delay getting modern Copyflex is costing you time and money. Make the experience of Chrysler Corporation your basis for mailing the coupon below. You'll be glad you did!



Shown here is the impressive battery of Copyflex machines used by Chrysler Corporation for important reproduction operations in vital missile work. Machines need no venting, plumbing, or auxiliary equipment . . . provide Chrysler Corporation with important operating benefits.

Copyflex Gives You All These Advantages

Greater Convenience of Operation! Modern Copyflex gives printing widths up to 54" to simplify feeding of large tracings, facilitate multiple feedings. Such features as extra-large delivery trays, automatic separation, and front-or-rear delivery further speed operator's work.

Faster Mechanical Speeds! New Copyflex models introduced within the past two years offer sharply increased speeds — up to 30% faster than before. Synchronized exposure and development assure top quality prints, one knob control simplifies operation.

Problem-Free Installation and Operation! Clean, quiet, odorless . . . Copyflex requires no vents or plumbing, needs only an electrical connection for operation. Precision-engineered design, including use of selenium rectifiers instead of troublesome vacuum tubes, assures trouble-free operation.

BRUNING *Copyflex*

Offices in Principal U. S. Cities

Charles Bruning Company, Inc., Dept. 123-0
1800 Central Road, Mount Prospect, Illinois
In Canada: 105 Church St., Toronto, Ont.

Please send me information on the Copyflex process and Copyflex machines.

Name_____ **Title**_____

Company_____

Address_____

City_____ **County**_____ **State**_____

Here's Fine Line Etching ... 375 Times Enlarged!

Actual Size

This is what Taylor means by *better* printed circuits . . . the unretouched photograph above is an enlargement of the miniature etched test coil shown at right. Here is a dramatic illustration of exactly what Taylor means by saying rolled copper-clad laminates give you *better* printed circuits. Enlarged 375 times, this photograph shows how the .002" wide conductors are parallel and free of pits, pinholes and lead inclusions.

Here's proof of why you'll be satisfied with your printed circuits . . . if they're made with Taylor copper-clad laminates. You're assured of a uniform material, offering consistently satisfactory etching . . . better production rates.

For more detailed information on Taylor copper-clad laminates . . . for a discussion on how these laminates can help you produce *better* printed circuits . . . contact your nearest Taylor sales office.

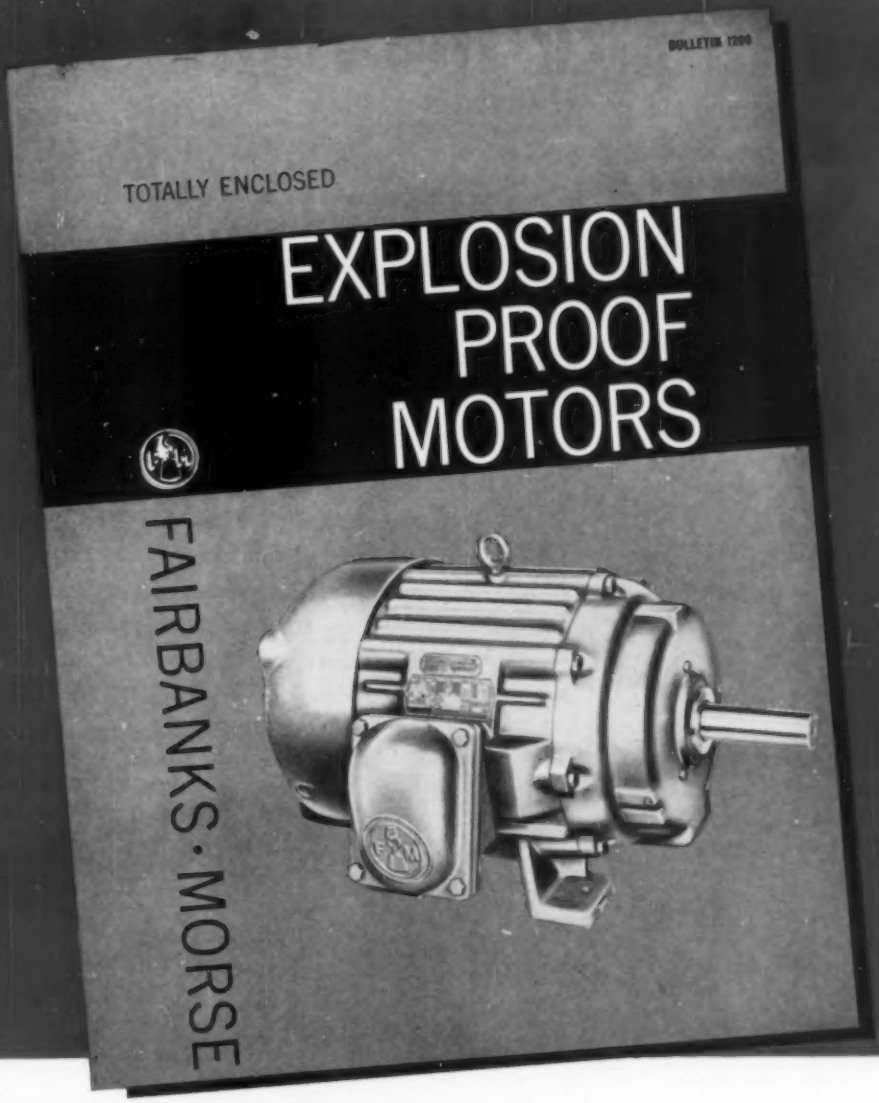
TAYLOR
Laminated Plastics
Vulcanized Fibre

FIRST AND LARGEST PRODUCER OF ROLLED COPPER-CLAD LAMINATES FOR BETTER PRINTED CIRCUITS

TAYLOR FIBRE CO., PLANTS IN NORRISTOWN, PA. AND LA VERNE, CALIFORNIA

INTEGRATED MANUFACTURER & FABRICATOR OF
Phenolic—Melamine—Silicone—Epoxy—Copper-Clad and
Combination Laminates • Vulcanized Fibre

NEWEST MOTOR TO CARRY UNDERWRITERS' LABEL



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All new inside and out—new, rugged frame design . . . for new, improved performance in all Class I, Group D, and Class II, Group E, F and G hazardous locations.

Get full information . . . send for Bulletin 1200 on new Fairbanks-Morse line of totally enclosed, explosion-proof motors. Write today: Fairbanks, Morse & Co., Dept. PE-12-23, Chicago 5, Ill.

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ELECTRIC MOTORS AND GENERATORS • DIESEL LOCOMOTIVES AND ENGINES • PUMPS • SCALES • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MAGNETOS

how to pick the right packing

To be sure that you get the *right* packing for *your* installation—put the problem up to Houghton's hydraulic engineers. They are backed by over 50 years' experience in hydraulics, and can give you sound answers.

Houghton makes all types of packings—rubber, rubber and fabric, rubber and leather, and leather. They know which type and style of packing will work best under a given set of conditions.

Call your Houghton Man and go over your packing problem in detail with him. The resources and hydraulic know-how of the entire Houghton organization are at his command to give you the right answer—and it costs you nothing. Call him or write today. E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

VIM and VIX-SYN PACKINGS
. . . products of

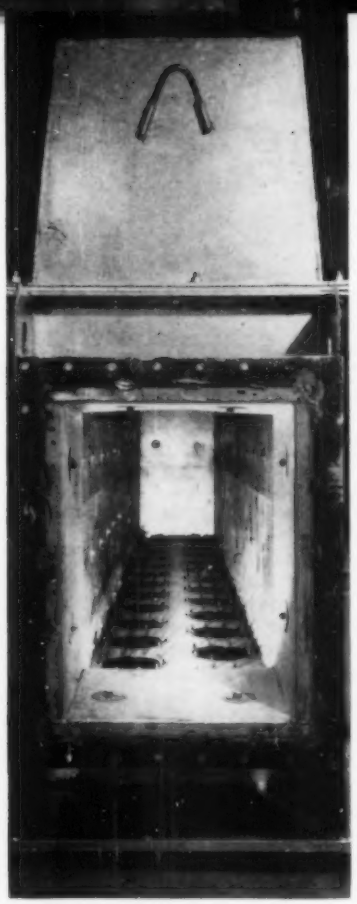
E. F. HOUGHTON & CO.
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . .

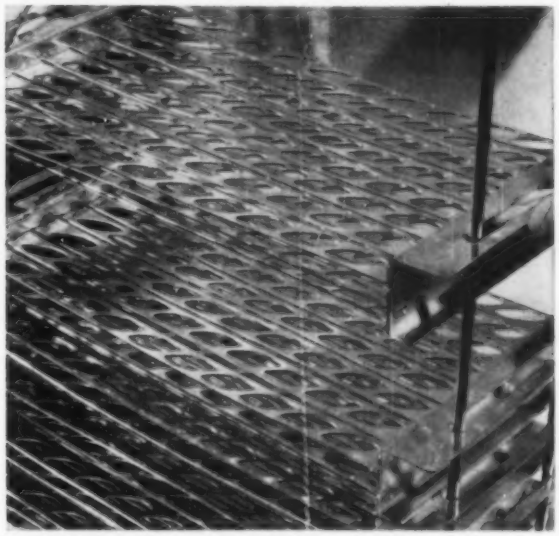
NOTHING can equal Stainless Steel

in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. For a reliable source of supply, United States Steel offers you the widest range of types, finishes and sizes. **Just call your steel warehouse.**



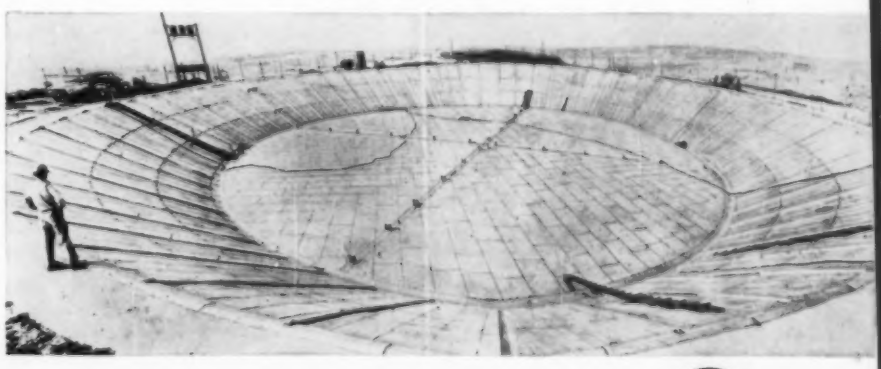
For High Temperatures. This recuperator is used on industrial furnaces. It uses waste flue gas to heat the incoming furnace air and thereby increase the efficiency of the furnace. Formerly, these recuperators were made with ceramic tubes, but heat transfer was low and leakage was high. The Hazen Engineering Company in Pittsburgh makes recuperators almost completely from Stainless Steel. Compared to ceramic designs, the Stainless design saves about 40% in fuel, increases furnace output about 10%-15%. The Stainless Steel performs well, even at this 1800-2300° F. temperature range.



For Cleanliness. When you work near nuclear radiation areas, you wear a small badge containing X-ray film that records how much radiation you have received. The film, "photo-dosimetric film," is developed in a Sensitometric Processing Unit made by Bar-Ray Products, Inc., in Brooklyn. The unit, including the trays shown here, is made completely from 18-gage Type 316 Stainless Steel because it resists corrosion, is easy to clean, has a hard, dense surface that doesn't harbor dirt.

United States Steel Corporation, Pittsburgh • American Steel & Wire Division, Cleveland
Columbia-Geneva Steel Division, San Francisco • National Tube Division, Pittsburgh
Tennessee Coal & Iron Division, Fairfield, Ala.
United States Steel Supply Division, Warehouse Distributors
United States Steel Export Company, New York

For Corrosion Resistance. The Hercules Powder Company needed an ammonium nitrate storage tank for their plant near Richmond, California. They took an old, World War I concrete reservoir and lined it with Type 304 USS Stainless Steel. The 14-gage sheets are laced with 18,000 feet of vacuum-tested welds. Tank holds two **million** gallons of solution, and is 200 feet in diameter at the top. U. S. Steel's Consolidated Western Division handled the complete installation.



USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL

Cross Wire Welding

How to Use It to Improve Product Design and Quality

What is Cross Wire Welding

Cross wire welding is a method of fastening wires or rods to one another at the point where the wires cross. It is a process that lends itself efficiently and economically to electric resistance welding techniques. In the extremely competitive wire goods field it is essential.

Done in this manner, a cross wire weld is a form of projection welding. The circumferential contour of the wire or rod itself causes the current to be localized at the point where the wires cross, generally at right angles.

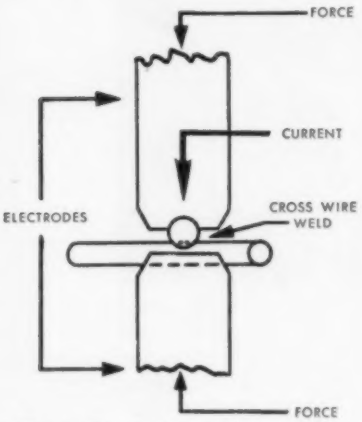


Fig. 1—Cross wire welding process.

The electrode dies which contain the weldable material are connected to a high current, low voltage transformer. Sufficient heat to weld is generated within the parts by the resistance of the metal to the passage of electric current. An electrode pressure forges the heated parts together until the proper amount of weld "set down" has been obtained which gives the piece part its necessary strength.

The term "set down" is the degree to which the wires are pressed together and is measured in terms of percent of wire diameter. It is dependent upon the amounts of heat (current), electrode force, and weld time duration.

STRENGTH OF CROSS WIRE WELDS

(Using Sciaky equipment with suitable settings)

Wire Dia. (in.)	Strength in Pounds					
	Cold Drawn Low Carbon Steel			Hot Drawn Low Carbon Steel		
	15% Setdown	30% Setdown	50% Setdown	15% Setdown	30% Setdown	50% Setdown
1/16	450	500	550	350	400	450
1/8	975	1,125	1,250	750	850	900
1/4	3,700	4,200	4,400	2,800	3,000	3,100
3/8	6,700	8,350	8,800	6,200	6,800	7,200
1/2	12,200	13,600	14,600	11,500	12,400	13,000

Advantages of Cross Wire Welding

Cross wire resistance welding requires no additional metal, arcs, gas or flame. *The weld is within the materials themselves*—and is as strong, if not stronger, than the parent metals.

Fig. 2—Typical cross wire weld section of wire basket.

Appearance is also an important advantage. Cross wire welding is currently being done so efficiently with Sciaky resistance welding techniques that little evidence of the weld is visible in the finished product. The small amount of upset is smooth without splashes or burrs.

Fig. 3—Diagonal cross section of cross wire weld. Diameter of wires are 5/16" and 3/16"—cold drawn mild steel.

Many products that were not originally designed for resistance welding can easily be adapted with simple tooling. Costly jigs and fixtures can be eliminated too. The capacity of Sciaky patented Three Phase resistance welding equipment permits tooling ingenuity to accomplish a quantity of welds per welder stroke impossible with conventional single phase equipment.

When to Design for Cross Wire Welding

As a rule, this application is done in multiple welds wherever wires or rods must be fastened to each other. Wire mesh, baskets, wire wheel disks are typical examples. A cross wire welding chart has been prepared to indicate obtainable strengths of welds of cold-drawn and hot-drawn low carbon steel of the same diameter.

Write Today for Free Sciaky Literature

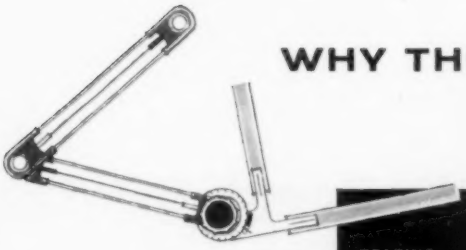
Start to build your data file on resistance welding today. Our "Resistance Welding at Work" publication, Vol. 3, No. 9, and Vol. 4, No. 1, contains case histories of Sciaky cross wire resistance welding techniques. Designers' Guide Bulletin 331 discusses other forms of resistance welding.

Describe your particular fastening problems on company letterhead and we will send suitable back and future issues of our "R.W.A.W." publication. All contain impressive examples of Sciaky's basic thinking—resistance welding techniques designed to put the profits back into manufacturing.

Largest Manufacturers of Resistance Welding Machines in the World

SCIAKY

Sciaky Bros., Inc., 4913 West 67th Street, Chicago 38, Ill., Portsmouth 7-5600



WHY THINGS RUN SMOOTHER WHEN YOU SPECIFY HYATTS

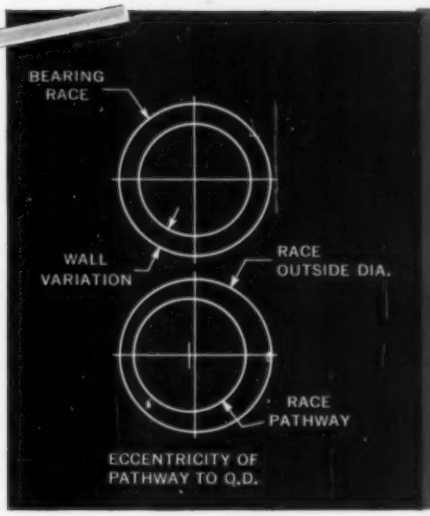


FIGURE 1

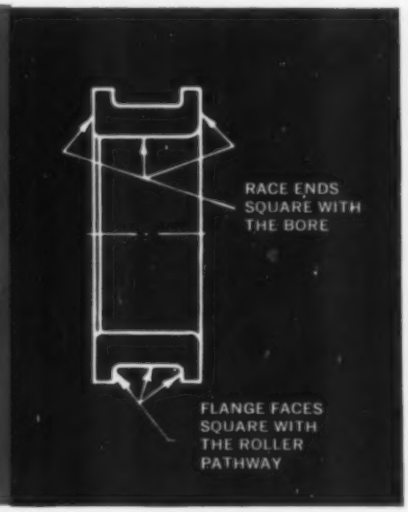


FIGURE 2

CLOSE CONTROL OF INTERNAL DIMENSIONS MEANS LONG, TROUBLE-FREE BEARING LIFE

The running accuracy and smoothness of a roller bearing is governed by the tolerances of its internal dimensions and clearance. Internal dimensions include concentricity of race diameters and squareness of all radial and axial surfaces, as briefly explained at right.

Because the internal dimensions of HYATT Hy-Roll bearings are so closely controlled, HYATTS run smoothly and quietly, last longer, and prevent equipment trouble due to excessive heat and vibration. You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; and Oakland, California.

Concentricity of race diameters is usually defined in terms of wall variation (Figure 1) of the individual races, and radial run-out of the assembled bearing. Squareness of race and roller ends and flange faces is vital to prevent roller skewing with consequent heating and noisy operation. Figure 2 indicates the race surfaces which must be square with each other within minute tolerances depending on the grade of the bearing. The roller ends must also be square with the diameter for the same reason as above. End square tolerances are usually less than .001" for the most frequently used sizes.

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

1908–1958

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

Unusually Tough BOLTS!

As vital parts of tractors, dirt movers and other heavy-duty equipment, these big bolts can take a terrific beating and still hold fast. They will resist shear, fatigue and impact that no common bolts could withstand without wear or breakage. Special heat-treatment produces this unusual toughness, making these National bolts capable of enduring extremely severe stresses.

By cold heading and special production methods, National can turn out many special headed-and-threaded fasteners which, like these bolts, solve special problems or reduce costs. Depend on National's extensive manufacturing facilities and complete line of fasteners for your needs.

Write for a free copy of National's "Special" fastener booklet.

Representatives in:

Chicago	Indianapolis	Philadelphia
Cincinnati	Kansas City, Mo.	Portland
Dallas	Lansing	Rochester
Denver	Milwaukee	San Francisco
Detroit	Minneapolis	St. Louis
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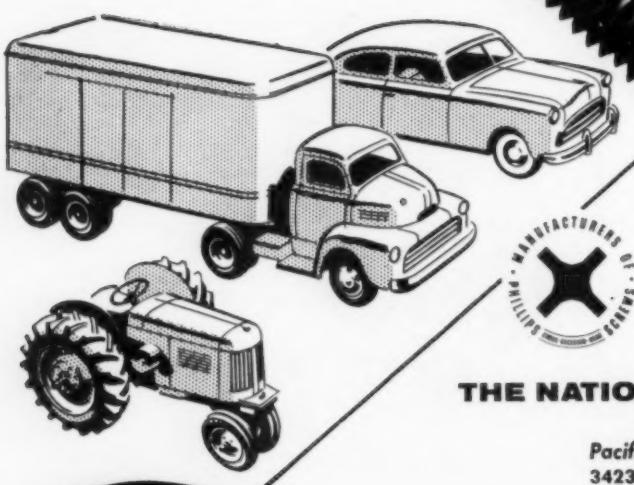

MANUFACTURERS OF PHILLIPS RECESSED HEAD SCREWS

THE NATIONAL SCREW & MFG. COMPANY
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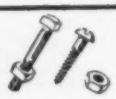
National PRODUCTS

Fasteners  Hodell Chains Chester Hoists

"With Weirkote® you can forget plating or dipping after fabrication. It just won't peel or flake!"

Q.—Weirkote—is that a new kind of steel?

A.—*"New" only to those who don't know of its advantages. It's a zinc-coated steel with a skin-tight surface, produced by a continuous galvanizing process instead of the old pot-dip method.*

Q.—Well, we've tried galvanized before for the parts and products we make. But it just couldn't stand up under the punishment of fabrication.

A.—*Must have been the old type galvanized. When you use Weirkote for fabrication, you'll find its surface stands up under the severest stresses. Punch it, lock it, crimp it, deep-draw it—its zinc coating stays intact. It's got a* built-in *resistance to peeling and flaking.*

Q.—Well, say—that'd save all the cost of plating or dipping after fabrication, wouldn't it?

A.—*Exactly! Plus assuring you a* uniform *protective coating at all times—something even a special coating doesn't always provide on the more intricately fabricated parts.*

Send today for free booklet that details the time- and cost-saving advantages of using skin-tight zinc-coated Weirkote. Write Weirton Steel Company, Dept. D-1, Weirton, West Virginia.

WEIRTON STEEL COMPANY
WEIRTON, WEST VIRGINIA
a division of
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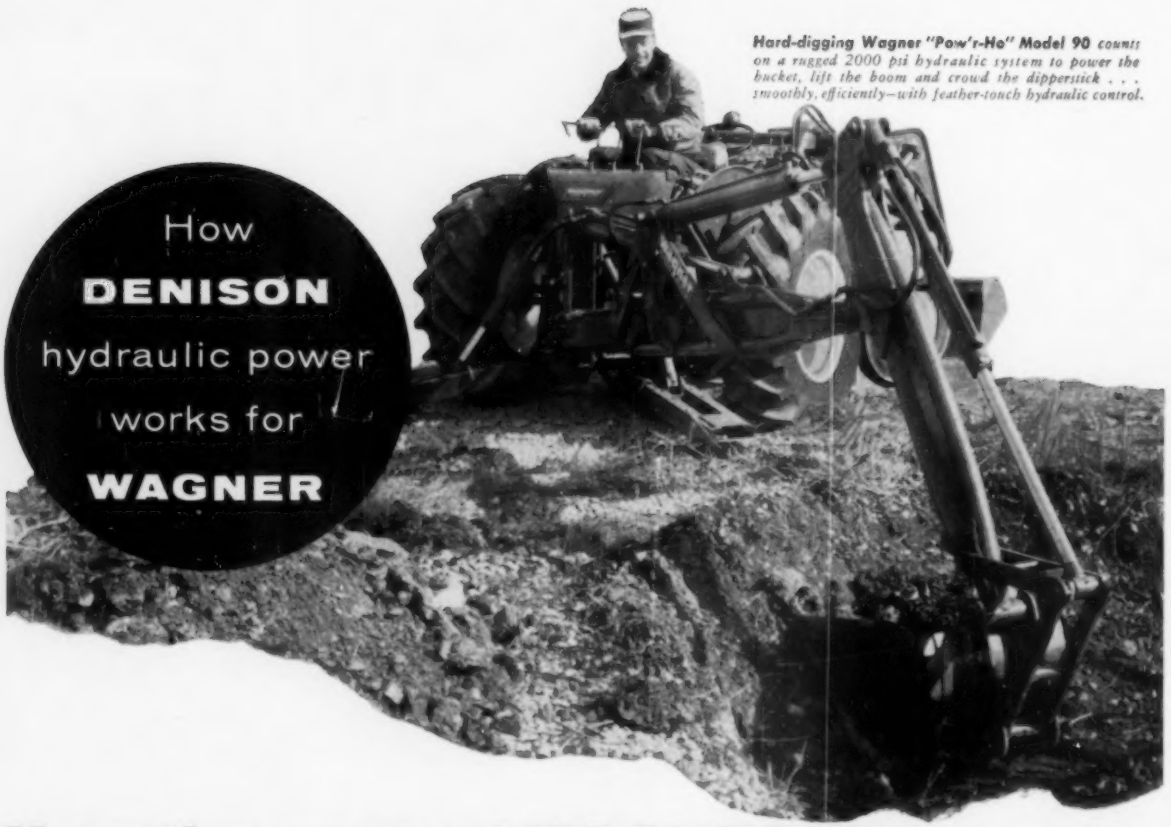
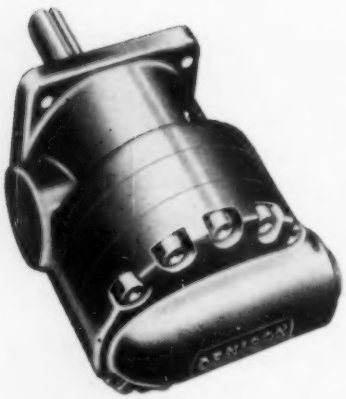


Hard-digging Wagner "Pow'r-Ho" Model 90 *counts on a rugged 2000 psi hydraulic system to power the bucket, lift the boom and crowd the dipperstick . . . smoothly, efficiently—with feather-touch hydraulic control.*

How the rugged WAGNER "Pow'r-Ho" bites 12-feet deep

. . . another application for DENISON hydraulic power



Hydraulic Punch *for the "Pow'r-Ho" is supplied by a single Denison 2000 psi TMC balanced-vane pump that actuates five hydraulic cylinders.*

Whatever the job—digging gas line . . . foundations . . . or drainage ditches—the rugged Wagner "Pow'r-Ho" Model 90 backhoe bites in hard, fast and deep with hydraulic muscle-power by Denison.

Five hydraulic cylinders—actuated by a Denison hydraulically-balanced TMC vane-type pump—power the bucket . . . lift and swing the boom . . . crowd the dipperstick. It's a fast, smooth, efficient operation—with power to spare, because a rugged, Wagner-designed 2000 psi hydraulic system and the Denison TMC vane pump make it that way.

Result: Harder digging with faster time cycles that mean *more profit* to the user.

It's the kind of job your Denison hydraulic specialist can help *you* do. Ask him more about how Denison 2000 psi pumps can improve the performance of *your* equipment. Write Denison Engineering Division, American Brake Shoe Co., 1194 Dublin Road, Columbus 16, Ohio.

DESIGNERS—ENGINEERS! Write for your copy of Bulletin 201—"How to Design More Efficient Hydraulic Power Into Mobile Machinery".

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HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

DENISON HydrOILics

Allen-Bradley Line
of MOTOR CONTROL
includes Both!

D.C. **A.C.**

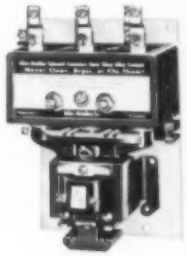
RELAYS AND CONTACTORS

Bulletin 200, Type G Relay. Rated: 5 amp, 64 v; 2 amp, 125 v; 0.5 amp, 250 v.

Bulletin 202 Contactor, Size 2, 1 Pole. Rated: 50 amp, 115-230 v.

D.C. relays are made with up to 8 poles. Also universal types, having contacts changeable from N.O. to N.C.—or vice versa—by merely reconnecting the terminals. Up to and including the 150 ampere rating, D.C. contactors are of the solenoid type; beyond this rating, up to and including 600 amperes, the clapper type construction is used.

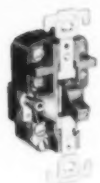
Bulletin 700, Type C. Rated: 10 amp, 550 v max.



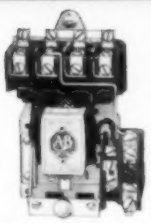
Bulletin 702, Size 2, 3 Pole. Rated: 50 amp, 550 v max.

A.C. relays are made in different types for various applications, with up to 8 poles. The universal type, having contacts changeable from N.O. to N.C.—or vice versa—is very popular. The A.C. solenoid contactors, made in 9 ratings up to 900 amp, 550 v max., will satisfy any service requirement. Silver alloy contacts are used throughout the D.C.-A.C. solenoid relay and contactor lines.

ACROSS-THE-LINE STARTERS



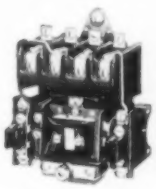
Bulletin 600, Form 52, double pole only, open type. Max rating: ¾ hp, 115-230 v.



Bulletin 209, Form 2. Max rating: 1½ hp, 115 v; 2 hp, 230 v.

D.C. manual starters have a rugged, snap action mechanism that prevents contact "teasing" and thus prolongs contact life. D.C. manual and solenoid starters have maintenance free, double break, silver alloy contacts. Motor overload protection is reliable.

Bulletin 600 in general purpose enclosure, complete with reliable overload breaker. Rated: 1 hp, 110-220 v.



Bulletin 709, Size 1. Rated: 7½ hp, 220 v; 10 hp, 440-550 v. Same general construction for max ratings of 300 hp, 220 v; 600 hp, 440-550 v.

All Allen-Bradley A.C. motor control is equipped with silver alloy contacts which are always in good operating condition. Because all A-B solenoid starters have only one moving part, trouble free performance and long life are automatically assured. It is the basic reason for Allen-Bradley's "quality" reputation.

A-B QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

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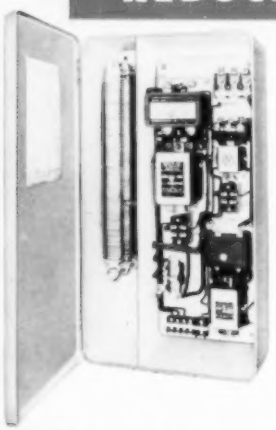
13-57-MB

...and more

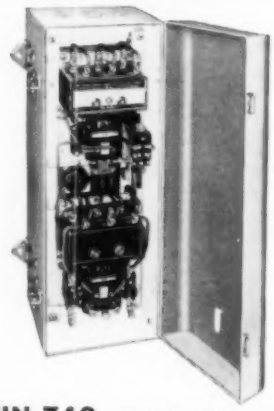
Allen-Bradley MOTOR CONTROL

D.C. | A.C.

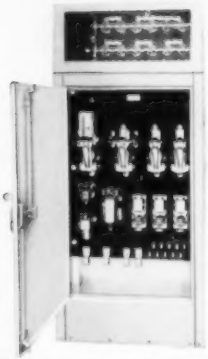
REDUCED VOLTAGE STARTERS



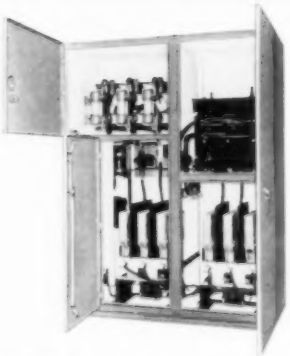
BULLETIN 267 are time limit, resistor type starters for automatic acceleration of constant speed shunt and compound wound D.C. motors. Solenoid contactors used up to and including Size 4 ratings. Max ratings: 75 hp, 115 v; 150 hp, 230 v.



BULLETIN 740 are graphite resistor type starters for automatic acceleration of squirrel cage A.C. motors. Made with 1 or 2 points of acceleration. Can provide velvet smooth acceleration for squirrel cage motors. Max ratings: 200 hp, 220-440-550 v.



BULLETIN 268 are time limit resistor type starters for automatic acceleration of adjustable speed shunt and compound wound D.C. motors. Designed for heavy duty service. Both Bulletin 267 and 268 starters available with or without dynamic braking feature, and also for reversing service. Max ratings: 75 hp, 115 v; 150 hp, 230 v.



BULLETIN 983 high tension starter illustrated above is of the reactor type, intended for starting synchronous motors. Available as an autotransformer reduced voltage starter; also in the across-the-line construction. The heavy duty, solenoid air break contactor assures long, trouble free life. Max ratings: 1500 hp, 2300 v; 2500 hp, 4600 v. at 0.8 P.F.

The Allen-Bradley *quality* line is *not* limited to alternating current motor control. A companion line of direct current motor control is available with the same outstanding *quality* . . . the same reliability . . . the same ability to "take it." Both lines are described and listed in our latest A-B Handy Catalog, and our trained field engineers will also be glad to help you with your control problems.

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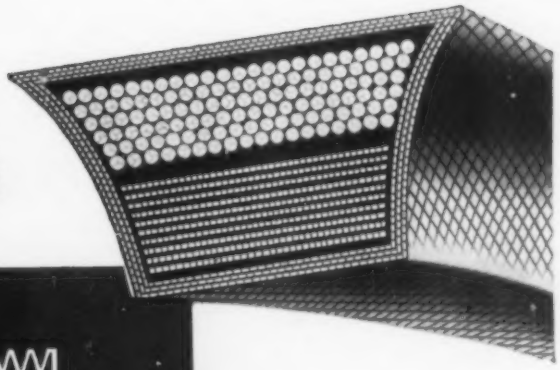

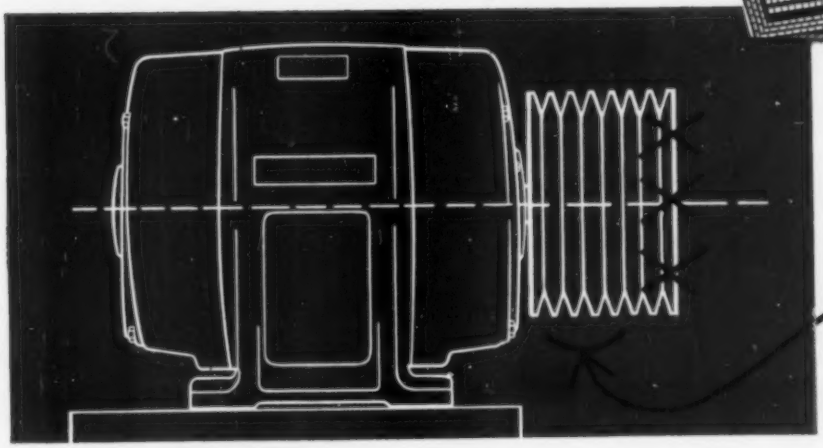

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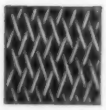

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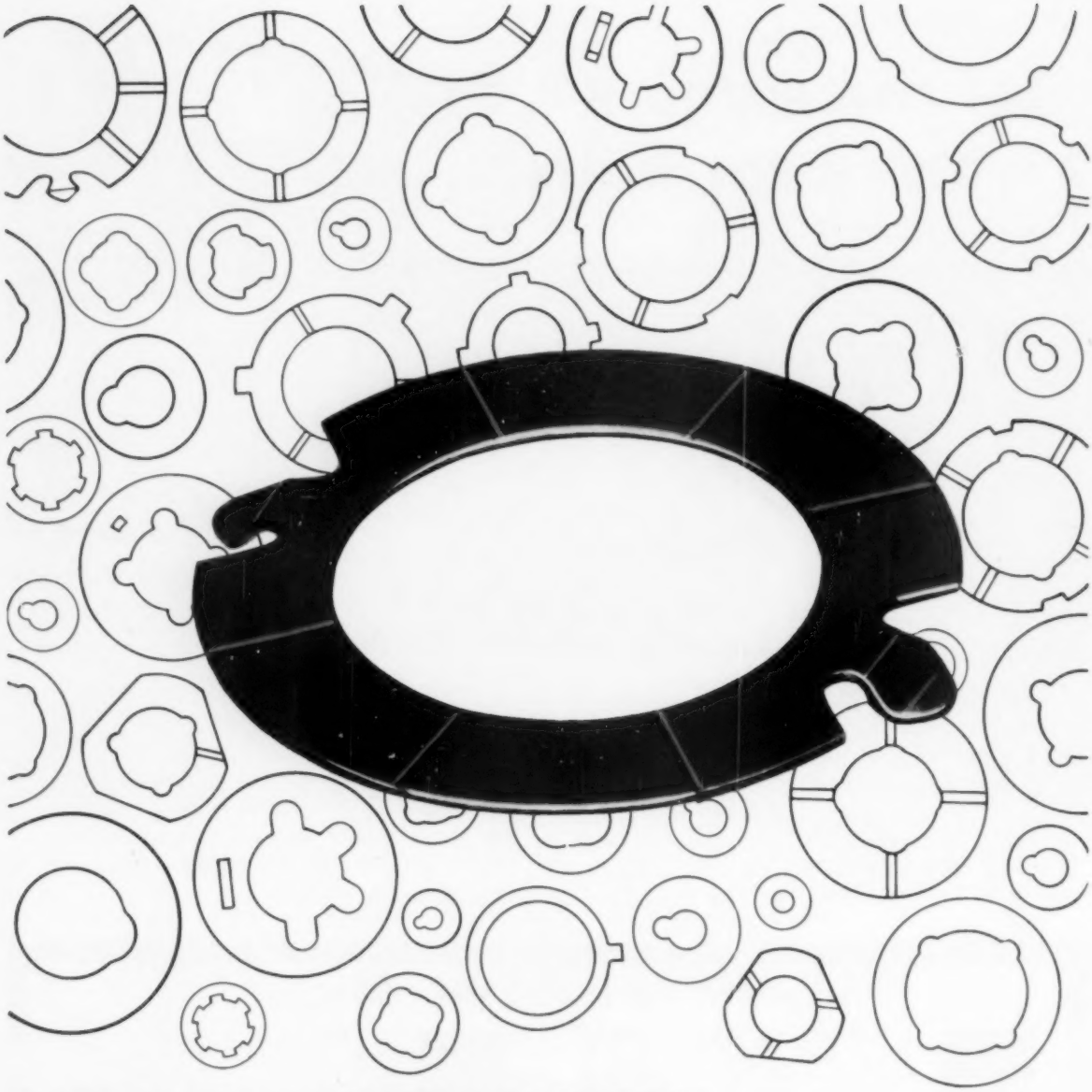

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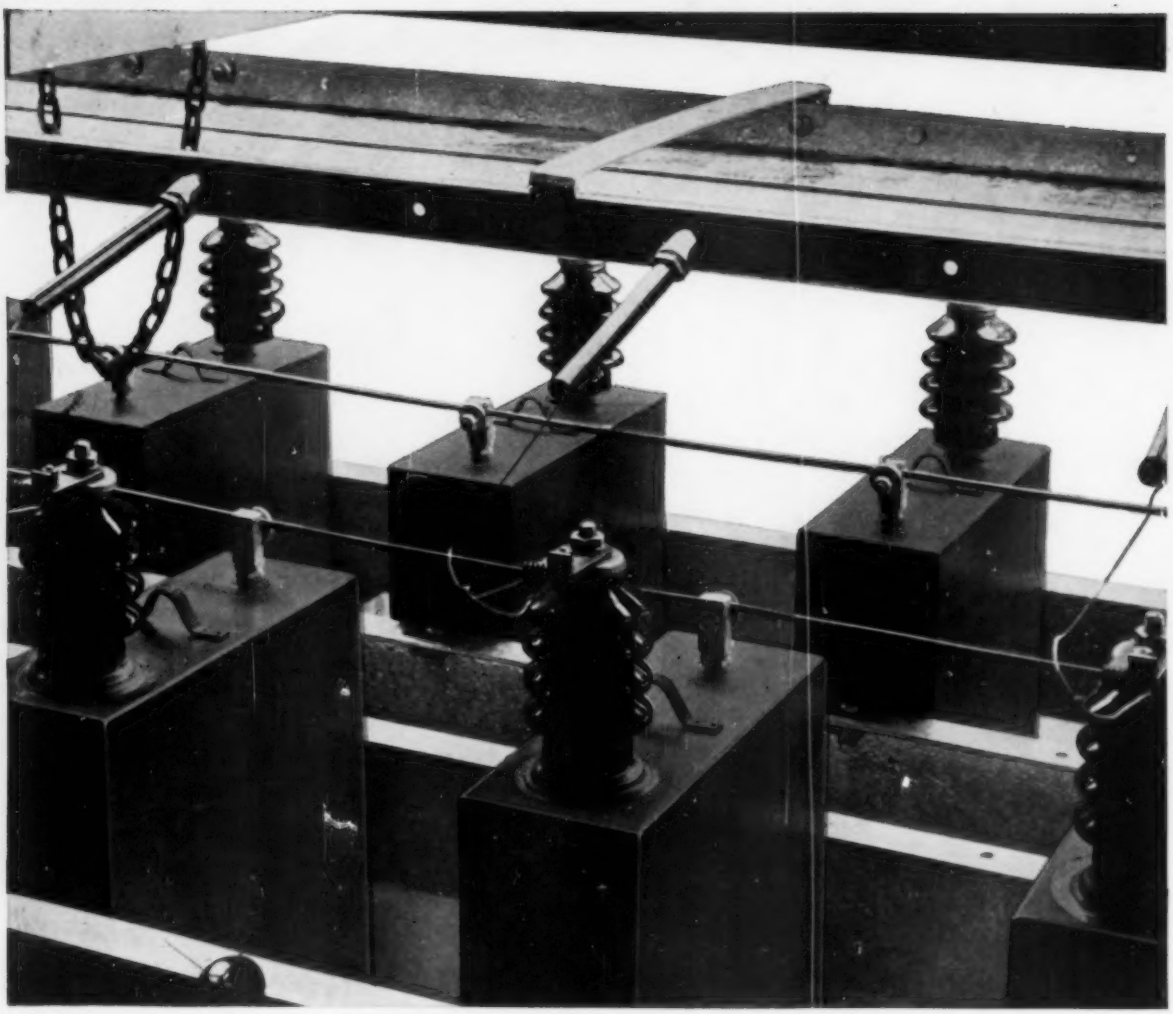

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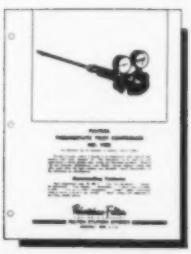

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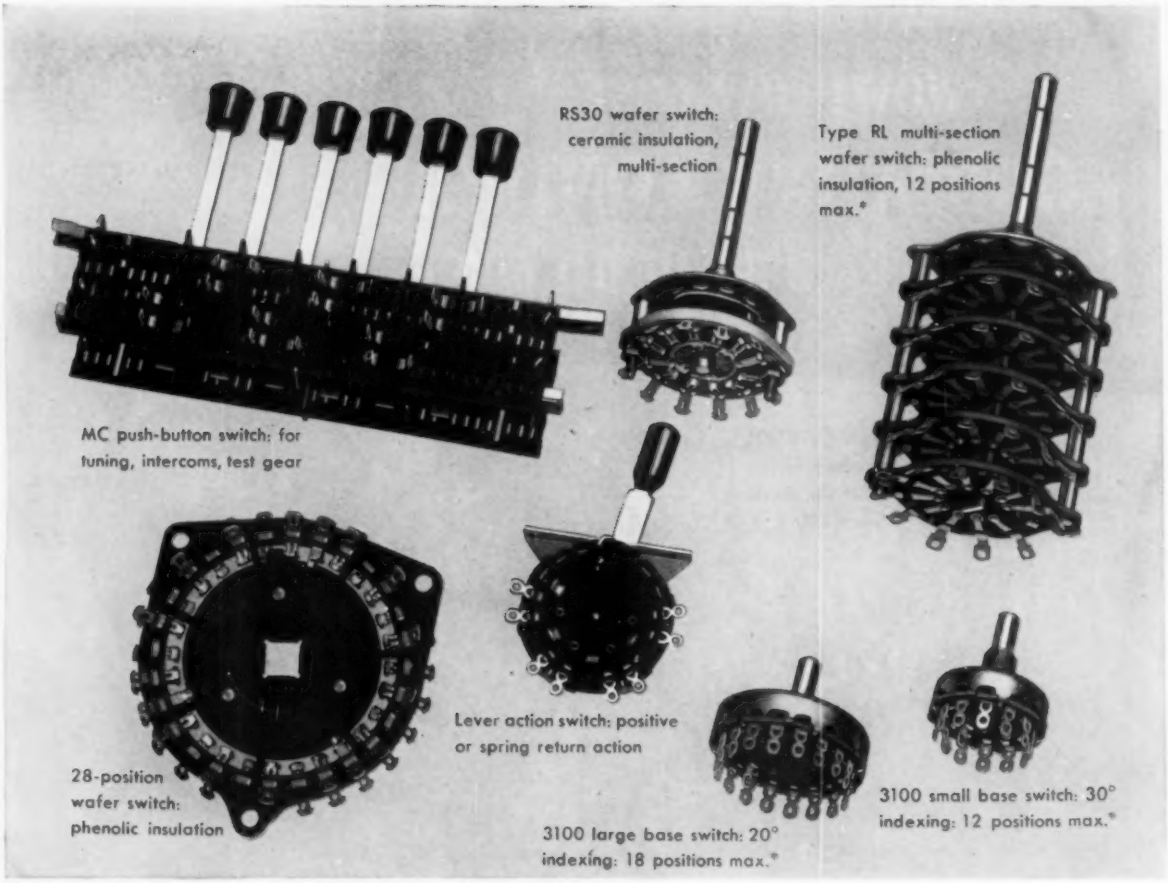
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If one circuit should fail, the rest will function without interruption, sharing the load between them. In critical applications this feature has no equal.

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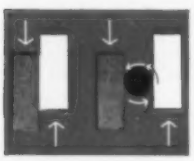
3. Precise Positioning. Machine-ground type will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0006 in./ft. of travel.

4. Temperature Tolerance. Normal operating range from −75° to +275° F.; in selected materials, will function efficiently at temperatures as high as +900° F.

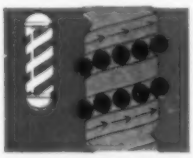
5. Lubrication Latitude. If lube fails, will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.

6. Fail-Safe Performance. Far less vulnerable than hydraulics; Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance against failure.

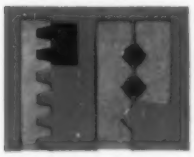
Here's why they're 90% efficient, save 4/5 on torque:



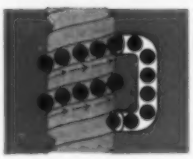
Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



the *Saginaw ball/bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

Available in custom machine-ground and stock rolled-thread types. Units have been built from 1½ inches to 39½ feet long—3/16 to 10 inches in diameter.

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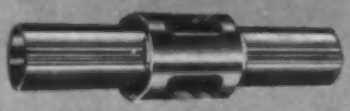
SAGINAW b/b SPLINE



This revolutionary new kind of spline utilizes the same basic principle pioneered by Saginaw in the ball bearing screw.

It permits new engineering designs never before practical—literally lets you achieve the "impossible"! In any application where column length must change under torque load, the Saginaw b/b Spline offers greatly decreased friction, less wear, longer life, more dependable operation. It can be fitted with integral gears, clutch dogs, bearing and sprocket seats or a wide choice of other attachments for use with electric, hydraulic or pneumatic units. To convert push-pull to rotary motion, helical types are available with very high loads, ranging from 20:1 to 100:1.

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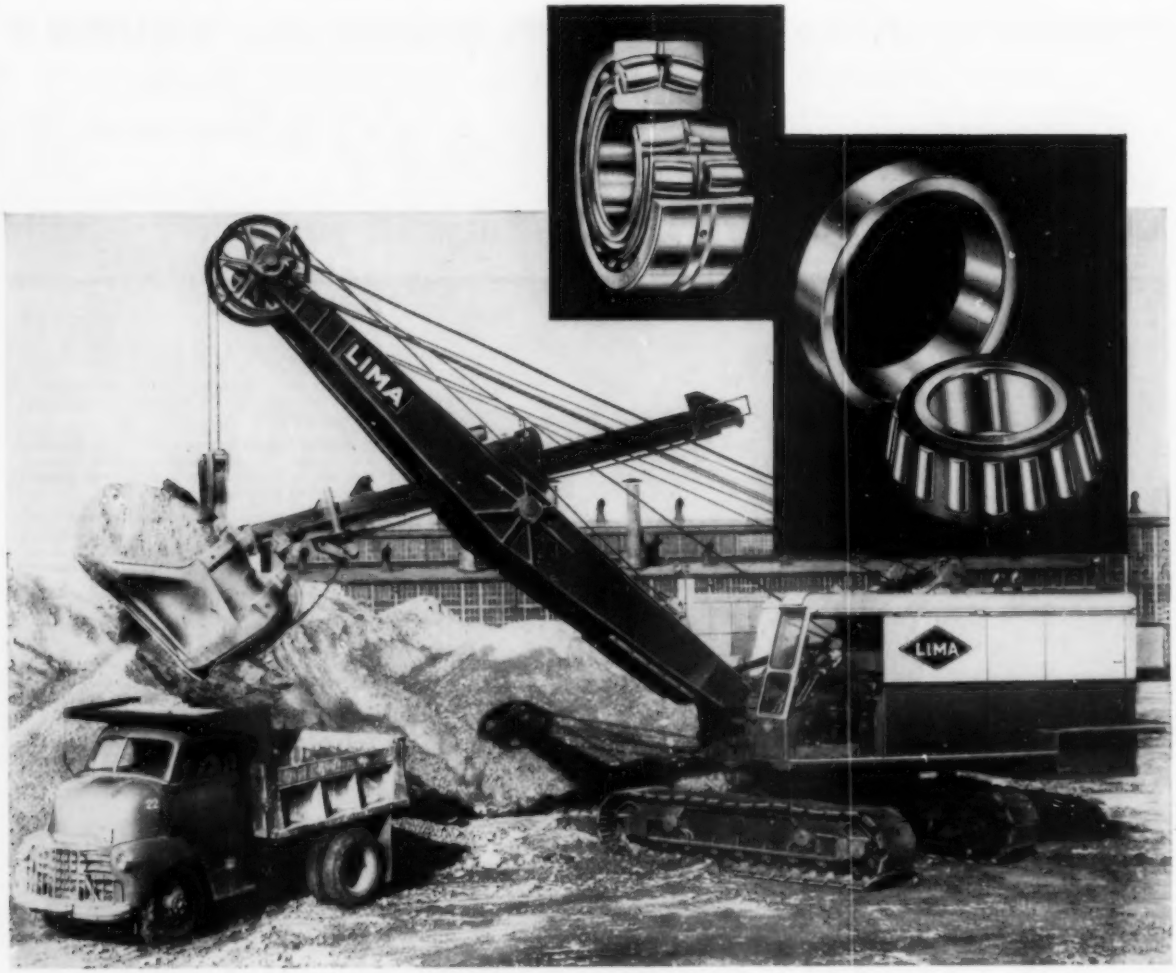

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This new valve replaces 12 previous models and it is interchangeable with all of them, also the drain connection is eliminated on the new valve to simplify piping.

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No need to stock several valves for wide range of flow rates. Drain connection is eliminated, piping costs are reduced.

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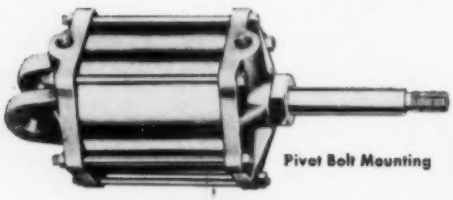
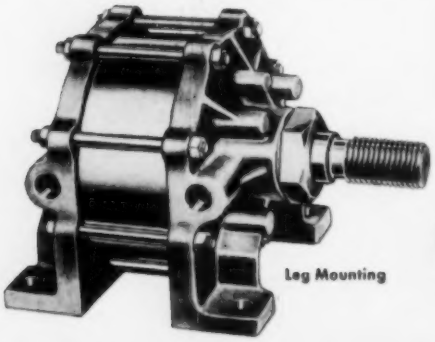
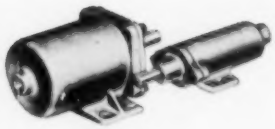


Pivot Bolt Mounting

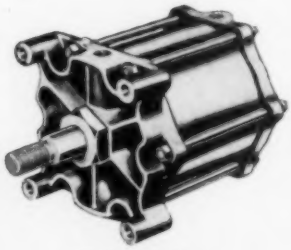


Leg Mounting

Base Mounting



Small Clamping Cylinders



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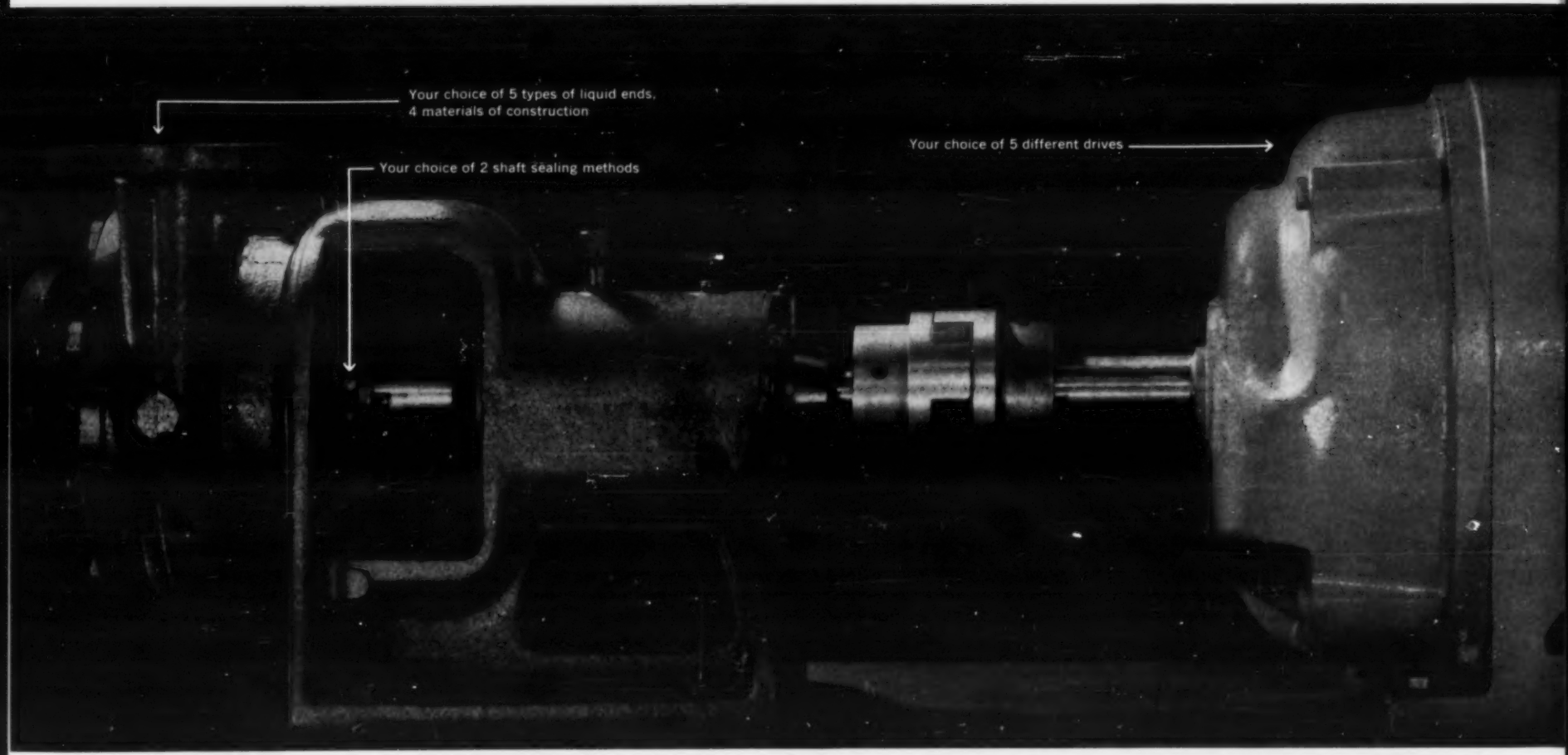
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Based on standardization of "parts" not "pumps" the SESC pump line gives you great flexibility in meeting special requirements in hydraulic coverage, corrosion problems and sealing methods *without* extensive design changes and modification expense.

For example, you have a choice of materials of construction–iron, steel, bronze, Worthite* and combinations of these–to meet all types of corrosive conditions. Hydraulic coverage can't be matched. There are 120 different sizes with ratings up to 2,700 GPM and 550 ft. head. You have a choice of stuffing box or mechanical seal operation. Both open and enclosed impellers are available.

Your Worthington representative will be happy to discuss the SESC pump program with you to see how it can improve your product's performance or reduce engineering and design expense. Or write for a copy of Bulletin W-300-B4B. Address Section SP-77, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955 Ltd., Brantford, Ont.

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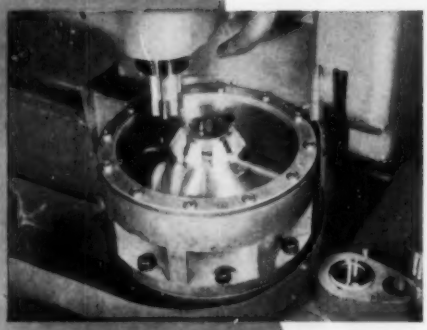
WORTHINGTON

How Gear Shaper *Versatility* helps IMPROVE DESIGN



Quick-acting, air-operated diaphragm chuck speeds loading and unloading of pump rotor on Fellows No. 7A-Type Gear Shaper.

The Gear Shaper principle of generating with a reciprocating tool provides a versatile and economical method of manufacture which allows the engineer much greater latitude in the design of parts for low cost production. Special fixtures and controls permit cutting gears, intricate contours and other shapes in tandem or combination where otherwise, special-purpose machines might be required.

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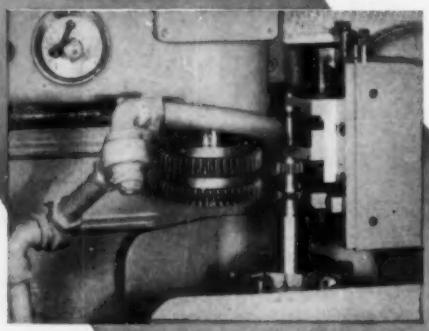
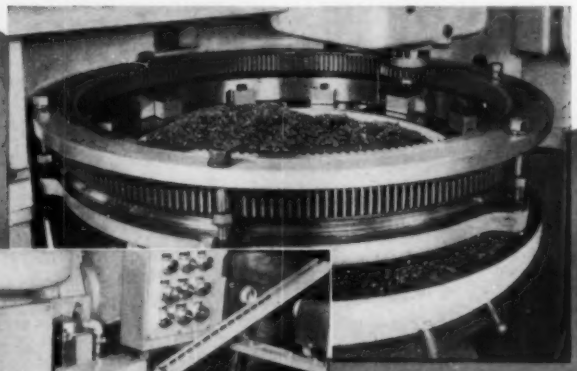
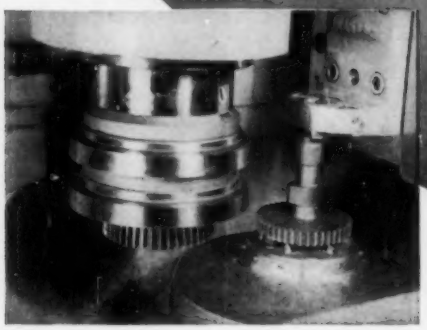


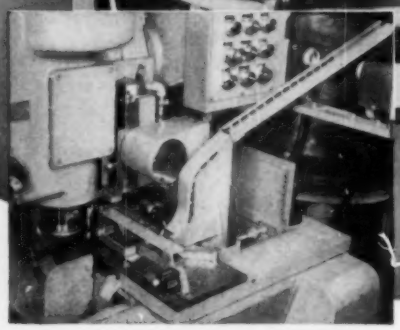
Two Gear Shaper Cutters in tandem cut automotive gears simultaneously. Center support fixture holds part in No. 4GS Gear Shaper.



Special fixture holds combination internal-external gear while internal gear is cut on 36-Type Gear Shaper.



Two cams and one gear are cut simultaneously on a gasoline motor part. Center support fixture holds part in No. 4GS Gear Shaper.



Fixture for automatically loading and unloading automotive pinions on the No. 4GS Gear Shaper.

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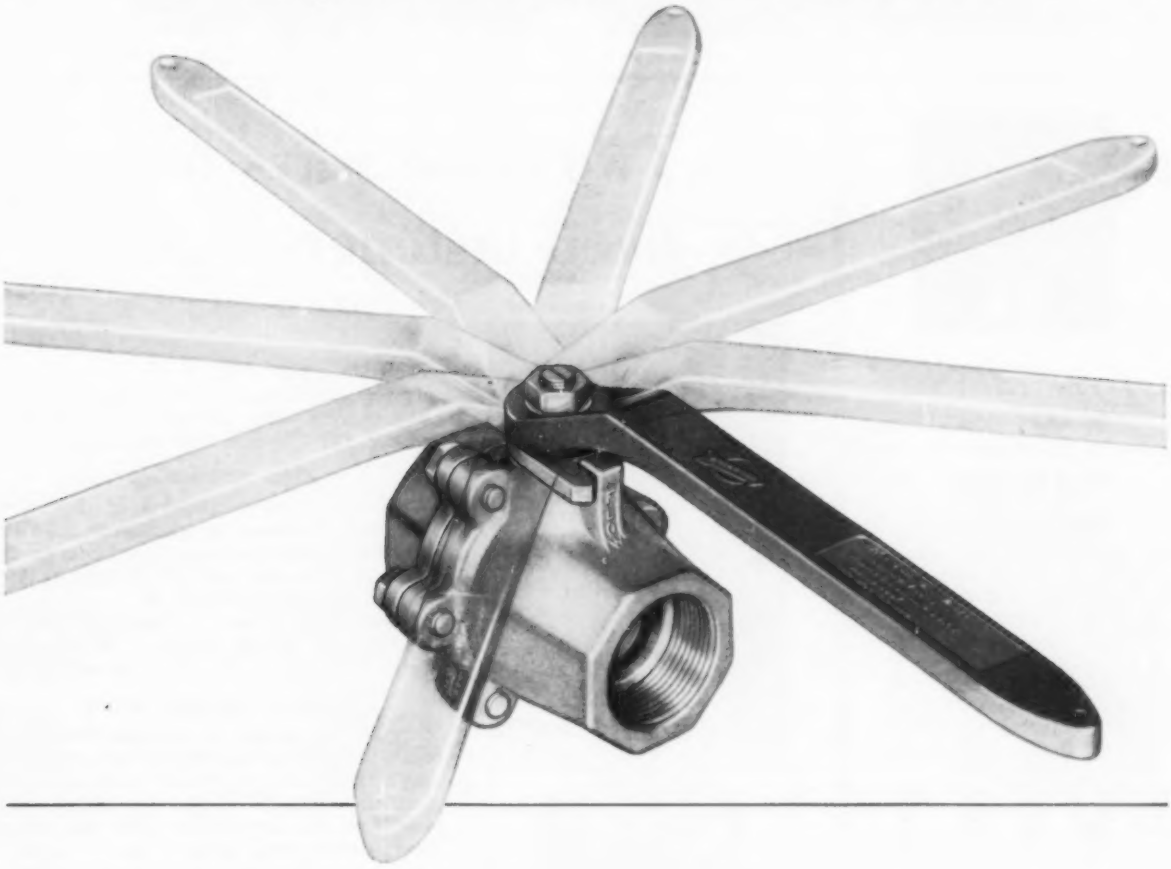
8 Ways Easier to Handle!



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Technical-ities

By John S. Davey

How to select tapping screws

1. Use *thread forming* screw Type A, B or C when material is ductile enough to stand deforming action of screw. If not, use *thread cutting* type.

2. Type A is used with pierced hole for starting; and where an exposed point doesn't matter. All other cases use B, C, or other blunt screws in drilled holes.

3. When load is no factor, metal gauge determines diameter of screw. Pick a thread pitch which gives at least a full thread engagement.

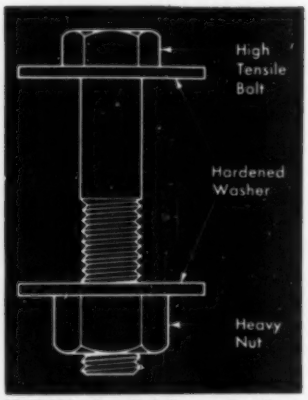
FOR EXAMPLE: Metal .062" thick suggests use of #7 Type A or #10 Type B (both have 16 threads/inch).

$$\text{PITCH} = \frac{1.00}{16} = .0625"$$

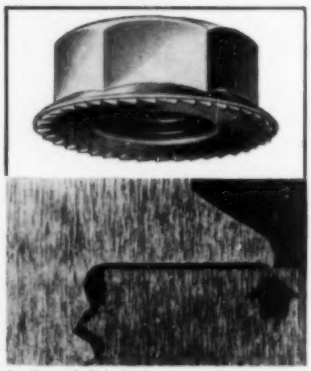
4. When you do have loads to sustain, you must consider required holding power. If metal thickness doesn't allow ample thread engagement (so that threads strip), use more smaller diameter screws. They engage more threads. Limiting factors: the screw's torsional strength, and the effort to drive it.

5. If, due to material thickness, screws fail by torsion or drive too hard, select cutting screws (1, F, or 23). For hard ductile materials, the Type 1 is best; for soft, friable materials, the Type 23.

Two basic ways to keep fasteners tight



RB&W high strength bolts permit optimum tightening without crushing surface when used with hardened washer.



Section of Spin-Lock screw. Teeth embed only with proper tightening. Same feature available in nuts.

Fasteners that stay tight keep joints strong. Resistance to loosening depends largely upon: (1) The inherent "locking" ability, (2) The man with the wrench.

HIGH PRELOADING

With rigid type joints, one of the best "locking" fasteners is a standard RB&W high strength bolt or cap screw . . . *torqued up close to its yield strength.* It locks by its own internal residual tension.

High tension not only keeps it permanently tight, but also prevents fatigue, assures optimum load capacity and safety.

INTEGRAL LOCKING DEVICE

Suppose the design of fastened members can't take full advantage of such preloading? Then a lock is needed, such as that furnished by RB&W Spin-Lock® screws and nuts. Ratchet-action teeth bite into seat; require 20% extra torque to loosen.

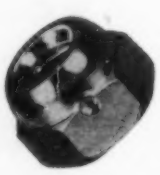
Note that Spin-Lock fasteners seat solidly before locking. The installer can't be deceived. He *has* to tighten properly before feeling resistance.

In both cases above, *positive* tightening assures positive fastening.

Send for Bulletin on Spin-Lock fasteners, or call your local RB&W Fastener Man. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Staked acorn nuts lock securely



Staking opposite sides of these RB&W acorn nuts deforms threads for a positive grip. It also puts middle of nut slightly out-of-round, for a spring tension locking effect. They're designed for applications such as outdoor furniture, where anchoring fasteners is more important than solid seating. Available in aluminum, steel, silicon bronze.

These all-metal nuts can also be furnished in regular double chamfered style. Since they lock with their middle threads, they can be turned onto screw from *either* side.

PERSPECTIVES

in design and development . . .

The Next One Hundred Years

Scientists have been called many things: longhairs; introverts; antisocial; dangerous (because they are in a type of work many people do not understand); and of course crack pots, to name a few. But at recent gathering of eminent scientists in New York they were told that they might well become the Herrenvolk, and that in the future world of scientific advancement the scientist will lead us into fascism.

The conclave was called the "Centennial Luncheon and Symposium on the Next Hundred Years," occasioned by the one hundredth anniversary of Joseph E. Seagram & Son. The purpose of the gathering was to listen to the scientific advances predicted for the coming century. Here are some of the highlights of their predictions:

What We Can Expect

Dr. Albert Szent-Gyorgyi, director of the Institute for Muscle Research and twice winner of the Nobel Prize in medicine and physiology. He said that in the next hundred years we will be able to cope with diseases much better, prevent much human suffering, and extend man's life span. We will steal the secrets of the plants and learn how to make food out of sunshine. We may even learn how to make food out of atomic energy. We will learn how to make plants grow faster. And biochemistry will solve the problem of birth control thus adding to stabilization.

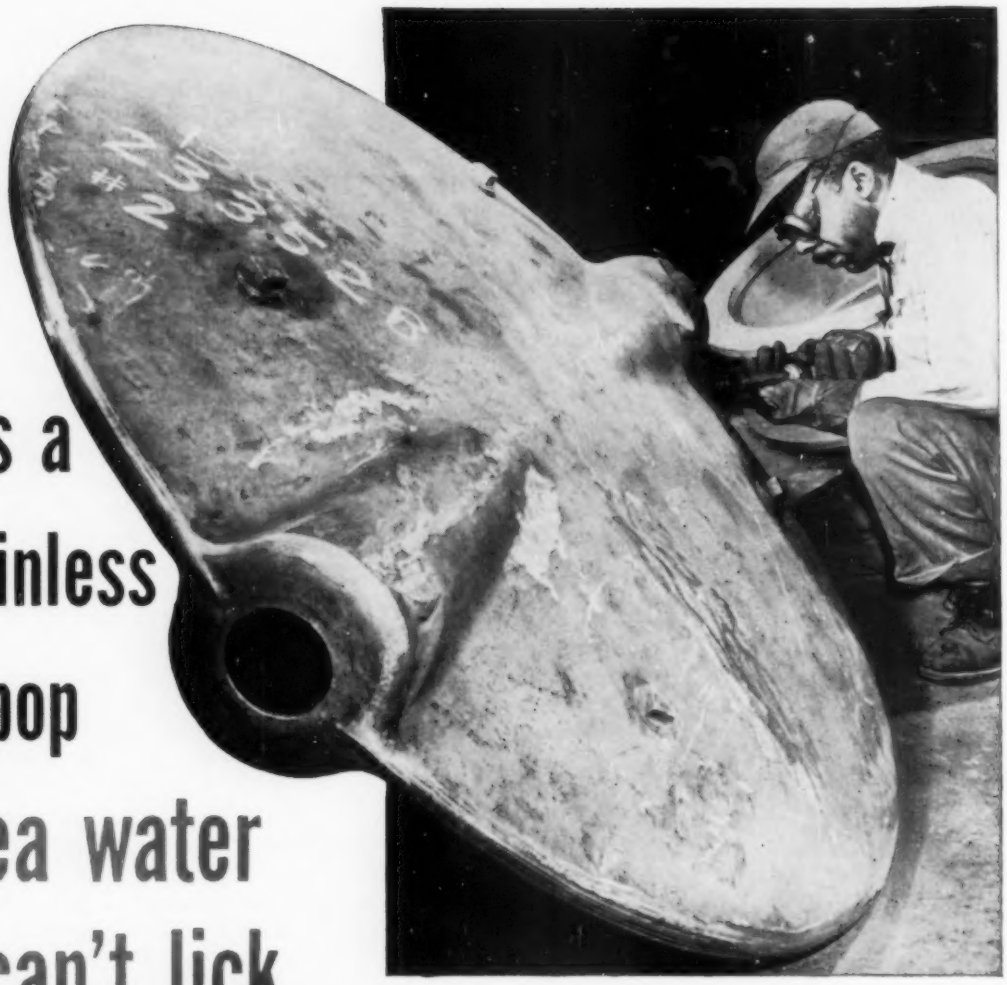
Dr. Harrison Brown, professor of geochemistry at the California Institute of Technology, said that we will learn to fulfill our needs for raw materials by utilizing the leanest of substances: ordinary rock, sea water, and energy from the sun. The world supply of atomic energy is almost inexhaustible. There are large reserves of uranium, and when these have been consumed, we can get more from ordinary rock. After that we have vast potentialities of thermo-nuclear power.

Dr. Clifford C. Furnas, Chancellor of the University of Buffalo, posed two questions: What makes grass green?; and how do oysters get their copper out of the sea water in which they live? Dr. Furnas said that when the chemical kinetics of these and a great many other biological processes are really understood, many new scientific fields will unfold. He said, "The next century will be one in which the chemist, and particularly the biochemist will play a very important role in scientific and technological progress." Just why grass is green involves photosynthesis, a process that is basic to all living matter, including ourselves. When we have a complete understanding of this process we will be on the threshold of the new radiation chemistry, for photosynthesis is a radiation reaction. Also, we will be able to improve on nature and develop processes for tapping the ocean for copper, zinc, chromium, vanadium, gold, and silver.

Dr. James Bonner, professor of biology at California Institute of Technology, predicted that the world will be compelled to go on a vegetarian diet in the next hundred years because of the rapid population growth. Deserts will be irrigated by water purified from the ocean. It will be possible to program an entire farming operation and leave the farm to run itself from a master computer panel.

Dr. Hermann J. Muller, world's leading geneticist and professor at the University of Indiana, and Nobel Prize winner in medicine and physiology said that in the next century it will be possible to prescribe the sex of a

(continued on page 53)



Here's a stainless lollipop sea water can't lick

This large (48″ dia., 1701 lbs.) and unusual stainless casting was fabricated by Allegheny Ludlum's Buffalo, N.Y. foundry. It is scheduled for service under the most severe operating conditions, functioning as a wafer valve disc at 25 psi pressure in sea water. Since long life and tight closing are essential in this application, corrosion resistant Type 304 Allegheny Stainless was specified.

Some unusual techniques were employed in the fabrication of this casting. Although the entire valve disc was cast as a single piece, its sides are hollow, with a skin only ¾″ thick. The center shaft was cast solid at the same time the side wings were cored, permitting the single piece, seamless part desired.

If you have a casting problem, or *any* problem that involves corrosion resistance, long life, resistance to wear and abrasion, call the Allegheny Ludlum Sales Office nearest you. An A-L Sales Engineer is ready to put his skills and those of the A-L Technical Staff promptly at your disposal, to serve your requirements from the largest and most complete line of stainless products on the market.

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child and to produce at will twins, either identical or fraternal, or even triplets. "With a more ethical attitude concerning reproduction, it will be regarded as a social obligation to bring into the world human beings as favorably equipped by nature as possible, rather than those who simply mirror their parents' peculiarities and weaknesses." The reproductive cells will be derived from persons long deceased.

Dr. John Weir, associate professor of psychology, California Institute of Technology said that ultimately we should learn to identify the neural network patterns that accompany specific thought or behavior patterns, and perhaps transmit these patterns to the brain circuits of another person without going through the present exchange of words and gestures.

Dr. Wernher von Braun, director, Development Operations Div. of the Army Ballistic Missile Agency, predicted that the U. S. will surpass Russia in conquering space, and that by the year 2057 voyages to the moon will have become commonplace.

Rulers of the World

After such an array of scientific predictions, the speakers were questioned by an interviewing panel of non-scientific news commentators who apparently were more concerned about scientists ruling the world of tomorrow rather than drawing out the scientists on some of their predictions. Members of the panel were John Daly, Chet Huntley, and Edward R. Murrow. Their questions went like this:

"Are you gentlemen at all aware that in our culture you could become the Herrenvolk; that the knowledge of the quantum theory is more important than the Bill of Rights, and that the scientist can come to dominate too much the culture in our society?"

"I wondered if what you have proposed does not, in effect, add up to the perfect fascist state in which there can be no dissenters. Does not everything that you propose fundamentally inhibit or destroy the whole competitive spirit of the human being and utterly destroy incentive?"

"Is it possible to develop a top scientist who will be a fully educated, fully developed man, all in a single person, or will the demands of science force us to breed scientists and depend on them for humanity?"

"We were told in our youth that a free science must be permitted to follow the truth wherever it might lead, yet in weapons, the Germans were ahead of us in WW II, and the Russians, in certain areas, are ahead now."

There was a ray of light when one of the interviewers referred to one of the predictions by the scientists, and asked: "I don't want to enter a note of levity into this heavy discussion, but would you tell me what the gourmet can look forward to with your steaks made out of vegetable matter and made chewy with plastic?"

Such were the questions asked of people who had much more to offer. Perhaps the interviewers were looking for some "grist for the mill" for a forthcoming report on "Scientists and Engineers: Future Rulers of the World." They certainly were not contributing to the answer of a question they themselves posed, which was by far the understatement of the day: "Does this not indicate that perhaps one of the basic things we have to solve in the next hundred years is a communication between the scientific fraternity and the great lay mass? . . . . Does science need to communicate more clearly to the mass of the American public exactly what it means?"

The answer to both parts is an unqualified "yes". But in answer to the first question as to what is needed in the next hundred years for informing the public of scientific developments, the interviewers showed that they were not getting off to an early start. —PAUL ANDERSON

ND FACTS

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Product Engineering

December 23, 1957

AGE OF FAITH . . .

In Europe, all during the Middle Ages, strong men devoted their lives to the quest for the Holy Grail, or joined Crusades to free the Holy Land. It was the Age of Faith, in contrast to our dawning Atomic Age.

High in the mountains of Albania, the "backward" land within the Iron Curtain and across the Adriatic from Italy, the Age of Faith has never ended. These fierce mountaineers lived for centuries under the yoke of foreign rulers, most of the time Asiatic Moslems, but they still retain the simple, straightforward Christianity that Saint Paul taught them two thousand years ago.

They will observe Christmas this year as they have for hundreds of years—the simple, yet impressive, acknowledgment of the birth of Jesus. There is a lesson for all of us in it, for High Albania is the land where they remember the Stranger at the Door and place above all else the caring for the guest beneath their roof, whether the world calls him friend or foe.

In High Albania, there will be no barbaric Christmas tree, no gifts, no selfish stuffing of humans. Albanians remember that Christmas is really Christ's Mass, a time for fasting, not for feasting.

Cows, goats, sheep and even chickens will be given an extra feeding before dark on Christmas Eve. The animals may not know, but Albanians will eat no meat for 36 hours, for they remember the animals in the stable in Bethlehem, who alone would make a place for the infant Jesus.

The housewife will have swept out her house, white-washed it from end to end, cleaned the hearth and laid a big log (like our Yule log). Everybody will eat the simple meal of fish in a semicircle about the hearth. The oldest man present then will light a candle and say a prayer. He will put a juniper branch on the log and lead a family chant while it crackles.

Then he will pour wine on the log and on the four corners of the hearth, for each corner saying a letter KRYQ—Albanian for "Cross." An unleavened loaf will be brought to the table. On it, the mother will set an apple with a sprig of olive stuck in it, and the part of the loaf beneath the apple will not be eaten for three days. Albanians remember the three days Jesus' body lay in the tomb, and recognize that birth and death are inseparable—the first must lead to the other.

Late on Christmas Eve, two sons will go to the family orchard. One will threaten each tree in turn with his axe, saying: "Will you give fruit this year or shall I cut you down?" His brother, speaking for (and from behind) the tree, will say, "I shall give you much fruit." Albanians remember the Biblical precept that living things must bear fruit, each unto his kind, and fruit is precious there. Trees, too, must be worth their keep.

Christmas morning, the head of the chief house of each village will rise at first cock crow to run through the streets crying: "Awake, O villagers, Christ is born!" Then every man of every house will fire a shot in acknowledgment. All will attend Mass, then they will come home to eat cooked wheat with melted butter poured over. (The mother of the house put a vessel of finest clean wheat to cook over the fire all night.) High Albanians remember that cooked wheat with butter is the shepherd's finest food—and shepherds first saw the Star, and worshipped the newborn King.

That is Christmas half a world away, Christmas which is really Christ's Mass, in the land where the Age of Faith has not died.

There, in High Albania, is a lesson for all of us.

K. S. Tangerman

WHEN SPLINES NEED STRESS CONTROL

DARLE W. DUDLEY

Manager, Advance Gear Engineering
General Electric Co., Lynn, Mass.

Correct diagnosis of spline-failure problems is a vital first step toward correct design. This article supplies charts and formulas for computing four important types of stresses that must not be exceeded.

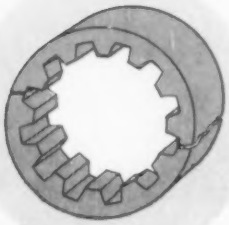
Splines may fail in one of these five ways:

(A) shaft of externally toothed member breaks underneath spline teeth

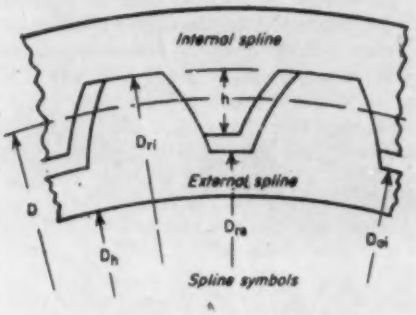
(B) teeth of spline shear off on pitch line

(C) teeth break at roots in a cantilever type failure similar to that of gear teeth

(D) contacting surface of spline teeth wear away by fretting corrosion



(E) shell of the internally toothed member ruptures



SPLINE SYMBOLS

A	height of crown
B	misalignment of spline, in./in.
D	pitch dia, in.
D_h	bore dia of shaft, in.
D_{oi}	outside dia of internally toothed part, in.
D_{ri}	major dia of internally toothed part, in.
D_{re}	root dia, also minor dia of external toothed member, in.
F	full face width, in.
F_e	effective face width, in. (may be less than F; see Editor's Note)
h	radial height of the tooth in contact, in.
K_a	application factor
K_m	load distribution factor
L_f	life factor limited by fatigue
L_w	life factor limited by wear
n	rpm
N	number of spline teeth
S_c	compressive stress, psi
S'_c	allowable compressive stress, psi
S_s	shear stress, psi
S'_s	allowable shear stress, psi
S_t	total stress, psi
t_c	chordal thickness at pitch line, in. (approximately equal to $D/2N$)
t_w	wall thickness, in.
T	torque, in.-lb = 63,000 hp/n
ϕ	pressure angle, deg

Spline design follows a simple procedure. Calculate the various stresses, then adjust size of the spline so that all stresses come within design limits. These four types of stresses are the major ones:

1. Shear stresses in spline shaft
2. Shear stresses in spline teeth
3. Compressive stresses in spline teeth
4. Bursting stresses in internal spline parts

SHAFT STRESSES

The externally toothed spline is cut on either solid or hollow shaft. Shear stresses induced in a solid shaft when transmitting a torque are:

$$S_s = \frac{16T}{\pi D_{re}^3} \quad (1)$$

For a hollow shaft:

$$S_s = \frac{16TD_{re}}{\pi(D_{re}^4 - D_h^4)} \quad (2)$$

Whether or not the shaft can withstand these induced stresses depends on the shaft material. Table I gives the maximum allowable shear stress S_s' for various types of steel. Computed stresses S_s from Eq (1) and (2) must not exceed the allowable stress S_s' in Table I, modified by application factor K_a and fatigue life factor L_f:

$$S_s \geq S_s' \frac{K_a}{L_f} \quad (3)$$

Application factors are listed in Table II. Note that relatively high service factors are used where both the driving and driven apparatus are relatively rough-running. Under normal conditions a generator represents a smooth drive; but a short circuit through a generator may develop a severe overload torque—and this possibility requires a high value of K_a in the shear-stress formula.

Fatigue-life factor L_f is based on the number of torque cycles. Generally, spline teeth get a cycle of load on and load off only when a machine is started up, and then later turned off. But some machinery—for example, power shovels, bulldozers, planers, shapers and airplane rudder controls—subject a spline drive to more frequent cycles of loading. Life factors for different torque-cycle values are shown in Table III. Unity life factor is taken as 10,000 cycles. If the torque cycles are known to be frequent, but difficult to determine accurately, a life factor for 10 million cycles should be used.

The allowable stresses given in tables represent the author's "middle of the road" recommendation for design standards. At present there are no generally recognized standards for intensity of spline loading. Perhaps these published values may become the basis for effective standards.

SHEAR STRESSES IN TEETH

Assuming now that the spline shaft can transmit the desired torque, the next potential failure spot is in the teeth. There are two ways they can fail: They may shear; or they may wear excessively because of high compressive stresses. Both possibilities must be examined.

Teeth are assumed to shear at the pitch line. The

TABLE I—ALLOWABLE SHEAR STRESSES FOR SPLINES

Material	Hardness, Brinell	Hardness, Rockwell C	Max Allowable Shear Stress, S_s', psi
Steel	160–200	.....	20,000
Steel	230–260	.....	30,000
Steel	302–351	33–38	40,000
Surface-hardened steel	.....	48–53	40,000
Case-hardened steel	.....	58–63	50,000
Thru-hardened steel (aircraft quality)	.....	42–46	45,000

TABLE II—SPLINE APPLICATION FACTORS, K_a

Power Source	Type of Load: Uniform (generator, fan)	Light Shock (oscillating pumps, etc.)	Intermittent Shock (actuating pumps, etc.)	Heavy Shock (punches, shears, etc.)
Uniform (turbine, motor)	1.0	1.2	1.5	1.8
Light shock (hydraulic motor)	1.2	1.3	1.8	2.1
Medium shock (internal combustion engine)	2.0	2.2	2.4	2.8

TABLE III—FATIGUE-LIFE FACTOR FOR SPLINES

No. of Torque, Cycles	Life Factor, L_f: Unidirectional	Fully-reversed
1,000	1.8	1.8
10,000	1.0	1.0
100,000	0.5	0.4
1,000,000	0.4	0.3
10,000,000	0.3	0.2

TABLE IV—LOAD DISTRIBUTION FACTOR FOR SPLINES

Misalignment	Factor K_m: ½-in. Face Width	1-in. Face Width	2-in. Face Width	4-in. Face Width
0.001 in. /in.	1	1	1	1½
0.002 in. /in.	1	1	1½	2
0.004 in. /in.	1	1½	2	2½
0.008 in. /in.	1½	2	2½	3

TABLE V—ALLOWABLE COMPRESSIVE STRESS FOR SPLINES

Material	Hardness		Max Allowable Compressive stress, S'_c, psi	
	Brinell	Rockwell C	Straight	Crowned
Steel	160–200	—	1,500	6,000
Steel	230–260	—	2,000	8,000
Steel	302–351	33–38	3,000	12,000
Surface-hardened steel	—	48–53	4,000	16,000
Case-hardened steel	—	58–63	5,000	20,000

TABLE VI—WEAR LIFE OF FLEXIBLE SPLINES

No. of Revolutions	Life Factor, L_w
10,000	4.0
100,000	2.8
1 million	2.0
10 million	1.4
100 million	1.0
1 billion	0.7
10 billion	0.5

TABLE VII—ALLOWABLE TENSILE STRESS FOR SPLINES

Material	Hardness		Max Allowable Stress S'_t, psi
	Brinell	Rockwell C	
Steel	160–200	—	22,000
Steel	230–260	—	32,000
Steel	302–351	33–38	45,000
Surface-hardened steel	—	48–53	45,000
Case-hardened steel	—	58–63	55,000
Thru-hardened steel	—	42–46	50,000

TABLE VIII—COMPARISON OF SPLINE MANUFACTURING METHODS

Method	Used on		General Comments
	External	Internal	
Broaching	No	Yes	Low cost for quantity production; high accuracy
Shaping	Yes	Yes	Low cost for small lot production
Hobbing	Yes	No	Low cost for small lot production
Shaving	Yes	Yes	For high accuracy, high speed couplings
Grinding	Yes	Yes	For highest capacity couplings
Casting	Yes	Yes	For small-dia nonmetal splines
Cold-forming	Yes	No	High-production, low-cost process for automotive parts

induced shear stresses are:

$$S_s = \frac{4TK_m}{DNF_c l_e} \tag{4}$$

In a spline, contrasted with a gear, tooth failure cannot stop the drive until all teeth are broken on both members. The constant 4 in the above equation assumes that, because of spacing errors, only half the teeth carry the load. With poor manufacturing accuracies, it is best to increase the factor to 6. Values for load distribution factor K_m, given in Table IV, are based on the amount of misalignment; K_m is 1.0 for a fixed spline (misalignment in a fixed spline is zero).

After calculating tooth shear stress, Eq (3) can again be used—to relate the calculated stresses with the allowable stresses.

COMPRESSIVE STRESSES

Compressive stresses act on the sides of the spline teeth and can be calculated from:

$$S_c = \frac{2TK_m}{DNF_c h} \tag{5}$$

Factor h is radial height in inches of the contacting tooth. If the teeth do not have a substantial tip radius or chamfer, then h is the sum of the addendum of the external tooth and the addendum of the internal tooth. If with chamfer or radius, subtract its average radial height from the sum of the addendums.

The constant 2 in Eq (5) assumes all teeth to be working, which becomes true after some initial wear.

Computed compressive stress should be compared with the allowable compressive stresses in Table V, by using these equations:

$$\text{Flexible splines,} \quad S'_c \geqq \frac{S_c K_a}{L_w} \tag{6}$$

$$\text{Fixed splines,} \quad S'_c \geqq \frac{S_c K_a}{9L_f} \tag{7}$$

The allowable compressive stress values are very much lower than those used for gear teeth because splines do not distribute the load uniformly between teeth. With typical misalignment, straight splines (a term used to differentiate from crowned splines) have only one end of the tooth loaded at a time. The full surface area of the spline is rather inefficiently used. Exceeding the allowable compressive-stress values results in fretting corrosion. The life factor L_w for Eq (6) is a wear-life factor, Table VI; the life factor L_f for Eq (7) is a fatigue-life factor, Table III. Wear life factors are based on revolutions of the spline—not cycles of torque on and off. Each time a flexible spline makes a revolution, there is a back-and-forth rubbing of the teeth which causes wear. In Eq (7), factor 9 indicates that a fixed spline has about nine times more ability to carry compressive stress than a flexible spline.

BURSTING STRESSES

Internally toothed spline parts tend to burst because of three different kinds of tensile stresses: (1) bursting stress caused by the radial force component at the pitch line, (2) bursting stress caused by centrifugal force, (3) tensile stress caused by the tangential force com-

ponent at the pitch line. The bursting stress caused by radial forces is:

$$S_1' = \frac{T \tan \phi}{\pi D t_w F} \quad (8)$$

The wall thickness of the internally toothed member is obtained by subtracting the major dia from the OD of the coupling sleeve, and dividing the result by two.

Bursting stress caused by centrifugal force may be estimated by the formula for a simple cylinder which assumes that the face width is less than one-third the pitch dia.

$$S_2 = 0.828(10^{-6})(n^2)(2D^2_{oi} + 0.424D^2_{ri})$$

The tensile stress due to beam loading of the teeth is

$$S_3 = \frac{4T}{D^2 F_e Y} \quad (10)$$

The Y-factor is the same as in the Lewis equation for gear design. Internal teeth of splines have a rather high Y-factor compared with gear teeth; usually equal to 1.5 or more. In most spline designs, it is not worth the trouble to make layouts to get an exact value for the Y-factor. Factor 4 in Eq (10) compensates for the load being carried on half the teeth.

All of the above stresses are tensile stresses at the root dia of the internally toothed part. The total stress tending to burst the rim is

$$S_t = K_a K_m (S_1 + S_3) + S_2 \quad (11)$$

This total can be compared with allowable tensile stress values in Table VII using the relation,

$$S'_t \geqq S_t / L_f \quad (12)$$

CROWNED TEETH

Crowned teeth on splines can handle a high amount of misalignment. Radii in the illustration can be obtained from these equations:

$$r_1 = 0.90(D/2)(\tan \phi) \quad (13)$$
$$r_2 = r_1 / \tan \phi \quad (14)$$

If the spline is fully crowned, the contact will stay fairly close to the tooth center even when the spline rocks through an appreciable angle. Fully crowned splines are successful with even as much as 3° misalignment.

If only slight misalignment is expected, the curvature of the teeth may be reduced, providing that dimension A is made greater than the quantity $BF/2$. This means that a spline of 1 in. face width misaligned 0.002 in. per in. should have a height of crown equal to at least 0.001 in.

When the crown is specified by the height of crown method, the approximate radius, r_2, may be calculated by

$$r_2 = F^2/8A \quad (15)$$

When a flexible coupling has sufficient crown, the width of the band of contact remains constant; Eq (5) is no longer valid for calculating the surface compressive stress. Instead a Hertz-stress formula must be used.

$$S_c = 2290\sqrt{\frac{2T}{DNhr_2}} \quad (16)$$

The computed value of S_c obtained above should be compared with the allowable values of S'_c for crowned splines, using Table V and Eq (6). Crowned splines never exceed the capacity of precisely aligned straight splines; the crown is only valuable in helping a spline carry a high amount of misalignment.

HOW DO SPLINES FAIL?

Splines transmit more torque for their size than any other type of coupler or joint. Frequently they are operating with a relatively small-dia shaft. Thus, the most common type of fixed spline failure is that of the shaft shearing.

Next most common is failure of tooth shear. Generally, the "fixed" spline (which mounts a gear, pulley wheel, turbine wheel, etc., in contrast with the "flexible" spline used as a coupling between shafts) has no relative motion between internal and external teeth to cause wear.

Fixed splines frequently carry high compressive (or "bearing") stresses and yet show no wear. When there is wear, it usually results from abnormal vibrations of the apparatus, or severe misalignment.

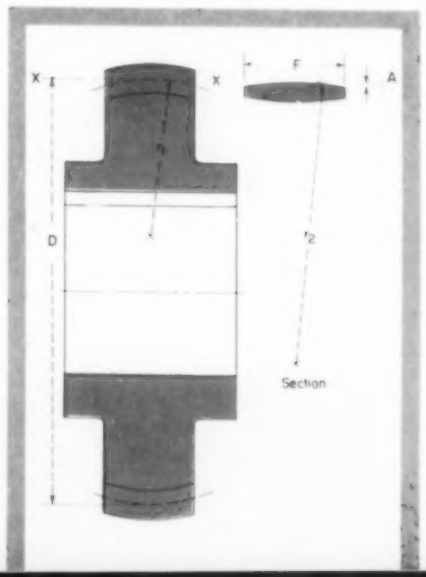
Fixed-spline teeth seldom fail in bending fatigue as in gear teeth because spline teeth are usually shorter and stubbier. Also a gear tooth is subjected to fatigue loading in which it receives a full on-and-off load each revolution—unlike fixed-spline teeth which do not have much change in loading per revolution.

Flexible splines are usually employed as couplings and do not carry as much torque per dia. There is little danger of the teeth shearing off. But there is some relative motion between teeth which makes them vulnerable to wear.

In larger spline couplings, the internally toothed member may burst because of applied torque. In addition, high speeds create severe centrifugal forces which add to bursting stresses. Even in small couplings, a thin wall on the internal member, a high tooth pressure angle, or a high torque loading for the size of the coupling can burst the internal member. In most

Crowned-tooth splines . . .

permit high misalignments—are often needed in couplings. Design procedure is same as straight splines except when determining radii define amount of crown.



Long broach . . .
cuts internal spline teeth in one stroke. Finished spline is shown with uncut piece at left. National Broach and Machine Co.

applications, however, flexible splines are not loaded heavily enough to burst without the added effect of high centrifugal stresses. But fixed couplings may burst even without any appreciable centrifugal stress.

FRETTING CORROSION CAUSES WEAR

Wear of gear teeth is caused by pitting or scoring. Neither of these things are common to splines. Spline teeth suffer the kind of wear called "fretting corrosion." Splines have an area contact instead of a line contact like gears. This keeps the compressive stress to low limits. A spline of 35 Rockwell C would seldom have a compressive stress over 10,000 psi, yet a gear of this hardness quite often has a compressive stress up to 100,000 psi.

In contrast with spline teeth which have almost no relative motion between mating teeth, gear teeth have a substantial sliding velocity. For instance, a 4-in. pinion at 10,000 rpm might easily have a tip sliding velocity of 2,000 fpm; a 4-in. spline at that speed will have less than 100. Since scoring is strongly influenced by sliding velocity and compressive stress, it is not surprising that scoring seldom occurs in splines.

The fretting-corrosion type of spline wear has its own peculiarities. It occurs in many kinds of machinery applications. Besides splines, ball bearing bores, parts keyed to shafts, bolted assemblies on moving parts, are all subject to fretting corrosion. Conditions that favor fretting corrosion are:

(a) Some small relative motion of the reciprocating type must occur between the contacting surfaces, with micro-in. movement and a frequency of over a few hundred cpm.

(b) Surfaces must be pressed together with at least a localized loading of a few thousand psi.

(c) Oxygen should have access to the contacting surfaces.

(d) No lubricant must be present. If present, it should be in limited supply so that it can break down with time.

(e) Similar metals and soft metals favor fretting corrosion.

This corrosion creates a red, rust-like sludge with a consistency like fine coffee grounds. A badly worn spline, 3 in. dia, may have as much as three teaspoons of sludge from fretting corrosion between the teeth.

The rate at which fretting corrosion proceeds varies widely. In some successful spline applications on aircraft engines, a flexible coupling—without lubrication—may wear at a rate of 0.010 in. in 1,000 hours. In some highspeed applications, over 10,000 rpm, fretting corrosion proceeds as fast as a rate of 0.001 in. per hour.

Control is just the converse of the conditions listed above: (a) either stop the relative motion, or make the motion great enough to develop a hydrodynamic oil film, (b) do not load the contacting surfaces too much, (c) provide lubrication with plenty of clean, highly-viscous lubricant, (d) use hard, metal materials as dissimilar as possible.

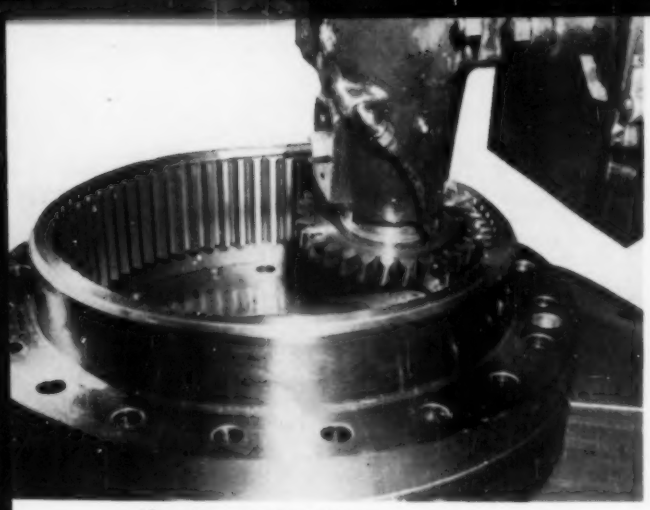
SPLINE MANUFACTURING PRACTICES

A wide variety of methods are currently being employed to make spline teeth. Each method has its own advantages and limitations, Table VIII, and often influences design of the spline. Broaching permits the smallest number of teeth, as few as six. Because of high pressure angles and shallow teeth, splines can take much smaller numbers of teeth without involute undercut than can gear teeth.

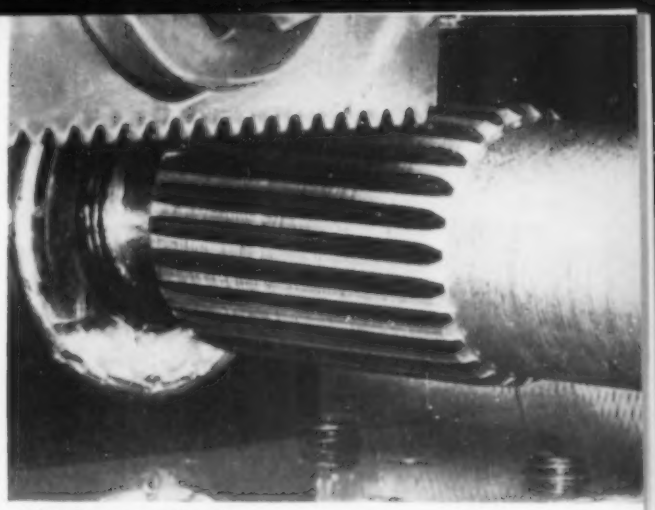
On the debit site, broaches are designed to accommodate a definite face width. Cost is less if a large face width is not used; face widths should be kept to within $\frac{1}{3}$ to $\frac{1}{2}$ the pitch dia. Another point to consider is that a broach requires a through hole in the part; obstructions may prevent pulling a broach through. Parts with obstructions some distance away from the end of the spline may be semi-finish shaped and then finished to size with a short "push" broach.

Broaches are popular for splines having a pitch dia less than 4 in. Some success is obtained for splines above 4-in. dia, but very large broaches are costly and heat-treating them successfully is quite a problem.

Shaping spline teeth with a pinion-type cutter is



Shaving operation . . .
on large spline coupler is easily done with standard-gear-shaving equipment. It improves surface finish and accuracy of form and spacing of teeth. Some machines can cut external teeth. *General Electric Co.*



Chipless production . . .
of 24/48-pitch, 45 pressure angle teeth of an automobile drive takes as little as 10 sec including loading time. Two opposing rollers (only top roller visible) operate as racks to coldform teeth. *Michigan Tool Co.*

common practice in almost any gear shop. Shaper cutters are less costly than broaches and can cut internal teeth in blind holes or external teeth very close to a shoulder. But they are limited in the minimum number of teeth they can cut. Smallest number of internal spline teeth of 30° pressure angle is 12. With other tooth forms the figure is even higher.

The hobbing process is popular for external-tooth splines. The spline should be designed so there is enough room for the job to "run-out" at the end of the face width. The hobbing process does not produce as high a fillet as the shaping process. The generating action of the hob is like that of a shaper cutter having an infinite number of teeth.

A hob can cut any number of spline teeth of a given pitch from the smallest to the largest. It has no serious limitation on face width. Some hobbing machines have been equipped to hob a crown in the teeth.

SHAVING PROCESS

Shaving is a finishing process that puts a good surface finish on the teeth and improves the spacing and involute-profile accuracy. External spline teeth are often shaved on large, high-speed splines. In certain applications, external spline teeth are shaved to have a slight crown.

The shaving process is somewhat impractical on 30° pressure angle splines of 50% depth. The number of teeth in the arc of action with the shaving cutter is just too small. Some manufacturers have attempted to get around this by making the splines with a longer addendum before shaving, and then cutting down the addendum to size after shaving. The 14½° spline with 39% depth is also no good for shaving.

An internal spline to be shaved should have over 40 teeth with a face width not over one-third the pitch dia.

Splines are only ground when a combination of maximum hardness and highest tooth accuracy is needed. Grinding—like shaving—is a finishing process. In the case of pitches finer than 20 pitch, parts can be ground from the solid.

External splines present no problem in grinding provided there is room for the runout of the grinding wheel. Small numbers of teeth can be ground. Internal splines must be fairly large to permit grinding. A 2-in. grinding wheel is about as small as practical. To get this wheel and its overhung mounting into the spline requires that the spline should be 4 in. dia or larger. But with special equipment internal splines smaller than 2 in. have been ground.

Some small spline couplings are made by die casting processes. Nylon is one material successfully employed to make small, lightweight couplings. On a weight basis their load carrying capacity is quite good. Powdered metals are also being used to make small couplings of medium capacity.

SPLINE ROLLING

A new and very rapidly expanding process is spline rolling. External spline teeth may be rolled into medium carbon steel shafts without any cutting. The process is extremely fast and the teeth that are rolled have a very smooth, accurate and work-hardened surface.

Rolled spline teeth require a high pressure angle and a relatively shallow depth. The 30° pressure angle spline with 50% depth works quite well in spline rolling. The 45° serration is also handy for rolling. Tests made recently by the author on rolled aircraft splines of 1-in. pitch dia and 20/30 pitch teeth showed that they would stand up just as well as cut and hardened splines. The rolled splines had a tooth hardness of about R_c 45 after rolling. Tests were made at 3000 lb-in. of torque, and a misalignment of 0.0047 in. per in. Splines may be rolled with any number of teeth—providing the shaft is strong enough to support the loads imposed on it during rolling.

EDITOR'S NOTE—For a thorough discussion of the types of splines as an aid in selecting tooth form, and for estimating size, face width and number of teeth, see Mr. Dudley's earlier article "How to Design Involute Splines," Oct 28 '57, p 75. This basic article evaluates six types of splines, presents design charts for making preliminary estimates as to size, face width, and number of teeth, illustrates the five most-popular tooth forms, gives recommendations for tooth tolerances and clearances, and points out the significant differences between aircraft, automotive and industrial-machine practices.

WARREN BOMHARDT
Materials Engineering, The Martin Cmpany

Designated 7079, this composition has lower notch sensitivity than alloy 7075 for thick-section applications requiring high strength. Here is a run-down on its advantages and limitations.

Navy's new jet plane has wings attached with inboard rib made from . . .

NEW ALUMINUM FORGING ALLOY

An aluminum forging material, alloy 7079, has just emerged from testing laboratories to challenge alloy 7075 and widen the field for high-strength alloys of this meaal. First major usc is the wing ribs for the production model Martin SeaMaster, shown above, to be delivered next month. Although not radically changed in composition, the new Al-Mg-Zn metal has:

- Better tensile strength in heavy sections.
- Higher ductility.
- Higher notch tensile strength.

It also offers some improvement in resistance to stress-corrosion cracking in salt water atmospheres. However, impact properties and those at elevated temperatures remain about the same for both alloys, and at very low temperatures 7079 is inferior.

Superior tensile strength and ductility of 7079 are attributed to its higher magnesium and lower zinc content. Corrosion resistance is improved by the lower copper and zinc content, and closer control of residual impurities.

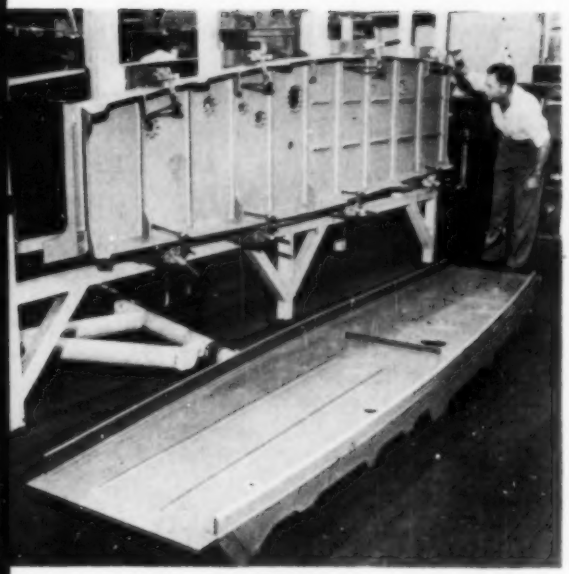
With alloy 7079, **tensile strength** is retained in sections thicker than 3 in. This makes heavy sections practical, enlarging the scope of application for high-strength aluminum alloys. But with sections below 3 in., the average for tensile strengths, both ultimate and yield, are about 5% lower than for 7075.

Notch sensitivity is much less with the 7079 alloy. This is a noteworthy advantage because few parts are made without including stress concentrations such as holes, welds or changes in section. Aircraft applications, particularly when using a notch-sensitive alloy, frequently require making prototype parts and then destructively testing them before design is approved. The lower notch sensitivity means less testing of parts is needed–reducing costs and cutting manufacturing time. At room temperature, the notch tensile strengths for this alloy are 4% to 13% higher than for 7075, and notch ultimate strengths are from 5% to 25% higher.

Corrosion characteristics of 7079 and 7075 in general are about the same. With stress corrosion, however, 7079 shows somewhat less susceptibility to cracking–a conclusion based on test specimens stressed to 50%, 75% and 90% of yield strength.

LIMITATIONS

Stronger than steel at low temperatures, alloys of aluminum perform better than ferritic steels below −40F. Tensile ultimate and yield strengths increase with decrease in temperature and the material does not go through a ductile-to-brittle transition. Ductility and impact strength decrease gradually through the whole range from room temperature to −320 F. The impact



Record-size forging . . .
of aluminum for this wing rib of jet plane is 150 x 35 x 7 in. It was made possible by high strength and deep hardening characteristics of alloy 7079.

Charpy V notch values drop from 4½ to 3 ft lb. At these temperatures standard unnotched tensile strength of 7075 is higher.

Fatigue endurance limits of notched and unnotched bars show no significant difference between the two alloys.

HOW TO USE 7079

The T-6 heat treatment for 7079 is as follows: Hold 4 hr at 830 F, quench in water with temperature between 140 to 180 F, age at room temperature for five days, age 48 hours at 240 F, then air-cool. The temperatures required for 7079 are 40° less for solution treatment and 10° less for aging. Lower solution-treatment temperature creates lower residual stress level in the material. After rough machining and heat treatment, this alloy can receive final machining with less distortion than shown by 7075. It is consequently recommended for large parts with unusually thin webs; and is readily adaptable for chemical milling where these extremely thin sections can be attained.

Design rules are identical for 7079 and 7075. Avoid sharp joints, use generous radii with gradual changes in cross-section, and polish where necessary. For forging, the same dies can be used without modification.

Specification of 7079 can be made as federal Specification QQ-A-367d or AMS 4138. It is obtainable as forging billets or extrusions. For the present, other commercial forms such as sheet, plate, and bar stock are not available.

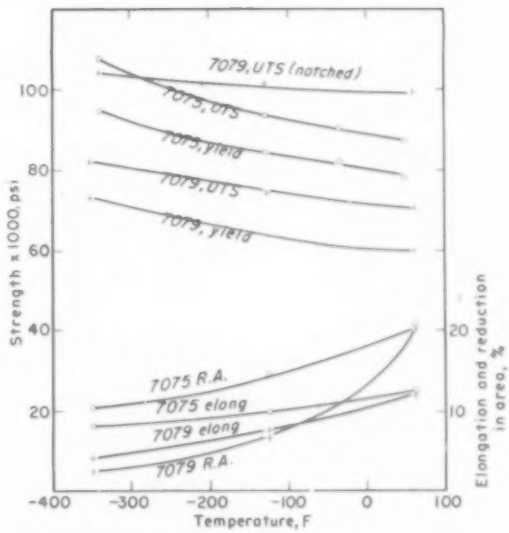
EDITOR'S NOTE: A coming issue will bring "High-integrity Aluminum Castings," an article on how to design and specify high-strength aluminum castings.

7079 vs 7075—Mechanical Properties (T-6 heat treatment)

Directional Properties	Standard		Notched		
	7075	7079	7075	7079	Increase, %
Yield Strength, psi					
Longitudinal	64,800	61,600	71,280	80,080	12
Short transverse	63,100	57,000	44,800	50,730	13
Long transverse	60,000	56,600	50,400	52,640	4
Ult. Strength, psi					
Longitudinal	76,500	72,600	84,150	94,380	12
Short transverse	69,700	68,300	49,490	61,790	25
Long transverse	70,100	66,400	58,880	61,750	5
Elongation, %					
Longitudinal	12.7	13.0			
Short transverse	2.7	7.8			
Long transverse	4.8	5.7			

Thickness in.	Cross-section, sq in.	7079			7075		
		UTS, psi	Yield, psi	Elong., %	UTS, psi	Yield, psi	Elong., %
up to 0.249	.....	75,000	67,000	7			
0.250 to 0.499	.....	74,000	67,000	7	75,000	64,000	9
0.500 to 1.499	.....	78,000	70,000	7			
1.500 to 4.99	up to 20	79,000	70,000	7	73,000	62,000	8
	20 to 32	77,000	70,000	7	73,000	61,000	7
	32 to 50	76,000	68,000	7	72,000	59,000	6
	36 to 144*				71,000	60,000	4
4.50 to 5.99	up to 38	78,000	68,000	6	Not recommended when over 3 in. thick		
	38 to 60	76,000	68,000	6			
5.00 to 6.99	up to 50	76,000	66,000	6			
	up to 60	74,000	64,000	4			

* 7075 with length over 3 in., has ultimate strength of 69,000 psi, yield strength of 58,000, and 3% elongation.



Low temperature . . .
increases strength and decreases ductility of both alloys, 7079 and 7075.

HOW TO

Here are two aspects — one from the viewpoint of the manager, one from the engineer — both thoughtfully presented.

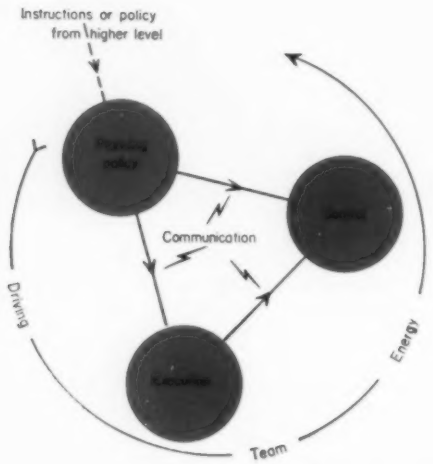
"You can talk all you like but you do not communicate unless you and the other man share the same thought," says J. Owen Dibbs in discussing the art of getting things done.

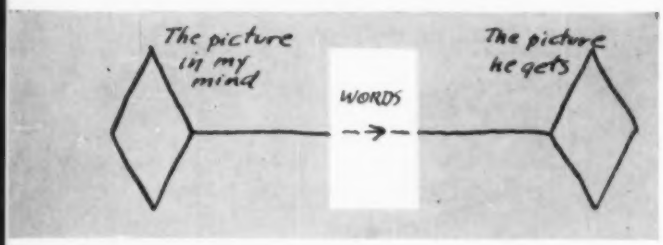
"The key to writing readable reports to management," says R. F. Philip, "is to communicate essential information, with major emphasis on conclusions and recommendations — and then stop!"

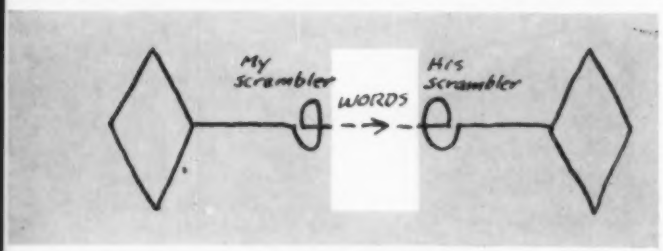
HOW TO MAKE INSTRUCTIONS CLEAR

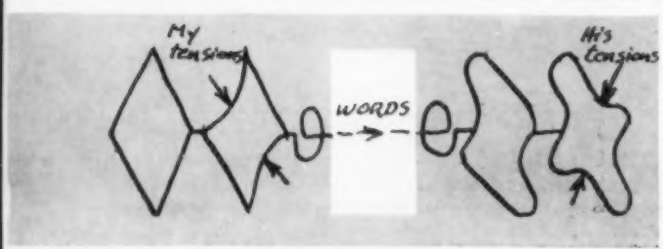
J. OWEN DIBBS,

Professional Directors and Associates, Ltd., Toronto









Leadership is the art of getting things done through people. It is an art, not a science; it can be learned, but is hard to teach; it can be recognized, but is hard to measure.

The mechanics of management, of which leadership is the largest part, look something like this circle.

1. As a manager, you receive instructions from, say, Head Office.

2. You work these into usable form for the men of your branch . . . you PLAN . . . then form your local, usable version of POLICY.

3. You get action from your men . . . you secure execution.

4. You check to see that the execution was satisfactory; you learn to do better next time; you CONTROL.

Between these processes you are involved in a communication—you cannot do without it. Communication comes from a French word meaning "to share"—you can talk all you like but do not communicate unless you and the other man share your thoughts—your understandings. Communication really means transferring a thought or an idea from your mind to his in such a way that he shares the thought with you. You get better, more successful, action when you can get him to see the picture in your mind—when you can see the picture in his, as he sees it!

In its simplest form, it should look like this (top diagram, at left).

But put yourself in the transmitter's place and then

COMMUNICATE

cast your mind back. If you will be honest with yourself, you will remember occasions when, just as the words left your mouth, you realized that wasn't just what you meant to say. Again, you may remember when you found that the other fellow didn't understand you, but after you had restated the thought, he caught on. Maybe you should have said it differently the first time.

This failure to translate your mental picture into words accurately occurs frequently without your being aware of it. In effect, we all have a "scrambler" between our original idea generator and our word selector. Similarly, our listeners all have their own scramblers, and so the picture changes to the second diagram.

But this is only the beginning. The picture you actually form in your mind is greatly affected by any surrounding tensions . . . by all the things that have ever happened to you . . . and especially by recent events. And when the receiver is an entirely different man operating under entirely different tensions, surroundings and feelings his picture (last diagram) really becomes distorted.

Now try constructing a diagram for two-way communication! What happens when the receiver merely tries to restate an idea back to the original transmitter?

This, then, is our problem. We speak our thoughts inaccurately, the listener receives them even more inaccurately, and then he evaluates them in terms of what he feels and thinks. Subconsciously he asks, "What did he mean by those words?" Of course, this isn't the whole story. There are many other complications and problems involved, but basically, the answer is to practice putting yourself in the other fellow's shoes:

- Concentrate on the thought he is trying to transmit. Try to see through his distortion.
- Concentrate on his feelings; avoid thinking about your reaction to his words.
- Restate his statement in your own words but in a form which he will accept as a true picture of what he thought.
- When he does not appear to have received you clearly, try to find what actual picture he did receive, and why.
- When you find two others having a problem in communication, try restating each man's point of view until each clearly understands the other's, even if he cannot accept it.

To the degree that others find you able to get a true picture of what they are thinking, they also will learn, and will try to share your thoughts. Now you are getting the benefits of two-way communication.

HOW TO REPORT TO YOUR MANAGER

R. F. PHILIP,

Asst. Dir. of Research, Hamilton Watch Co.

Management and engineering personnel are both pushed hard. Engineers are pressed with the responsibility of keeping pace with fast-moving technical developments and management is harassed by problems of directing this work into useful channels. But the two groups must work together. Communication, in the form of the technical report, is consequently a vital link guarding against misdirected efforts and uncertain objectives.

Reports written by busy people, for busy people, must be to-the-point, quick-reading; must focus major emphasis on conclusions and recommendations. Well-supported conclusions are the goal. And when they are reached—stop!

PLANNING THE REPORT

Most jobs can be made easier by thinking about them beforehand. Planning is as important in project report writing as it is in other industrial activities.

Planning the report involves, first of all, choosing the type that must be written. Reports for industrial research are five distinct types, each with its own essential information:

- **Feasibility report.** Recommendation for or against starting a development program.
- **Program Outline Report.** Jobs, time and costs broken down into significant phases.
- **Progress Report.** Completion of a phase.
- **Final Report.** Project summary with achievements and recommendations.
- **Procedure Manual.** Technical instructions.

Product of the report-writing operation is more than just a report, it is a communication of essential information. The entire writing process should hinge upon efficiently communicating this information.

But reports are passive. They do something only when they are read or, better still, used. Consequently, an important planning step involves making the report

readable. One fact is certain—a reader will use something he needs. But the specific needs of management are not as easily predicted by engineers as are the needs of the technically trained reader.

A manager's needs arise from his responsibilities and the limitations on his time. He is responsible for the investment of effort and funds of his company. As an investor he is interested in the answers to such questions as:

What is the proposal—what are the technical problems, and how much will it cost?

What are the favorable and unfavorable aspects?

How far has the program progressed?

What has been achieved?

How much money has been spent?

How much more will be spent?

What are chances of success?

What is predicted completion date?

What do you recommend?

Management's need-to-know will be satisfied when direct and clearly supported answers to these questions are the basic structure around which the report is built. Additional information, technical or financial, must meet the test of contributing to essential needs of management.

MECHANICS OF REPORT WRITING

Title page tells the reader what to expect. It gives him a preview of what area of interest will be discussed. Top-of-the-page position should be reserved for the type of report. Other items on the title page include identification, project number, project title, report title, assignment, authors, date, originating agency and location.

Table of contents tells the reader how the report is organized. If subheadings have been used liberally throughout the body of the report they can be repeated in the table of contents to provide quick reference to specific items of interest. When carefully chosen, subheadings can present the reader with a Table of Contents which is essentially a report outline.

An appendix is a convenient device. If it is properly assembled, the main sections of the report can be kept brief and to the point without sacrificing completeness. Material which adds to a better understanding of the report, but tends to divert the reader's attention because of its detail, can be removed from the body of the discussion and tacked on to the end. Each item added to the appendix should be identified in the Table of Contents and also should be easily located by page number.

Introduction to the report must describe the topic to be discussed and bring the reader up-to-date as rapidly and clearly as possible. Presentation of this material will vary with type of report.

For a Feasibility Report the introduction should state the proposition and review any special background. The introduction to a Procedure Manual should tell how to use the manual. For the Program Outline, Progress Report and Final Report, the quickest way to describe the over-all problem is to start with a recapitulation of the considerations made when the project was established. Scope, cost estimates, and time estimates are presented for refreshing the reader's memory and he is ready to follow into the latest information.

In Progress Reports and Final Reports the introduction can describe intervening work by including a general outline of the program on a second sheet and indicating the phases which have been completed. Expenditures to date, intervening revisions in estimated costs, and completion dates can be given also.

If detailed technical background material is considered necessary in the introduction it can be appended to the report and mentioned in the introduction as available.

SUMMARY FOR MANAGEMENT

Conflicting needs of the technical and managerial readers make it difficult to prepare a summary for both. To avoid this conflict, in each report which management should read, the summary should be written to meet managerial needs. In such cases it should be called Summary for Management.

The ideal summary should be held to one page without sacrificing clarity. It should be unnecessary to read the technical portions of the report to learn key points such as work done, conclusions reached, and recommended action.

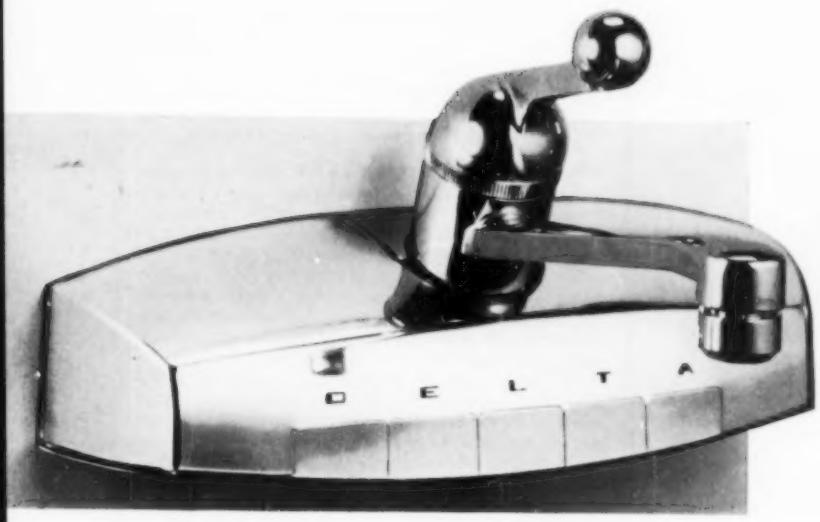
A general statement of the work done is sufficient, but should justify the investment required for the proposed program; for a program already established, the statement should justify initial enthusiasm for the project. The summary can restate final objectives in the light of current accomplishments and indicate remaining costs and estimates for date of completion. In completed projects, the achievements and recommendations for use can be emphasized.

TECHNICAL MATERIAL

Technical parts of the report can be written essentially for the needs of the technical reader. This change in reader needs does not mean a change in the requirements for brevity and clearness—but only a change in emphasis. In Progress and Final Reports, the chief concern is presentation of technical conclusions. The reader has to know what the conclusions are, on what information they are based, and how the basic information was obtained. He needs to understand the conclusions and judge their validity for himself. The writer can supply these needs in either of two ways: state the conclusions before giving the supporting results and the methods by which the results were obtained; or, describe the experimental methods first and follow them with results and conclusions. The order of presentation is a matter of choice but the pertinency is not.

Recommendations for action are made obvious to management by including them in the Summary for Management. The requirement for brevity at that part of the report may prevent a full statement of all the details and qualifying considerations. The complete recommendations can be given with the conclusions, or set up as a separate section.

The future work does not always need a separate section. The Program Outline Sheet may indicate the general nature of future experiments without requiring elaboration.



Matching chrome plate . . .
of faucet, the coating on this fixture hood was applied to underside of clear plastic. This gives desired appearance without subjecting thin film to abrasion caused by scrubbing and harsh detergents.

VACUUM COATINGS GO INDUSTRIAL

Once limited to decorative uses, vacuum-deposited coatings are now finding many industrial applications, such as in the corrosion-resistance and miniaturization fields. Improved production methods have kept pace.

PHILIP J. CLOUGH
Director, Metallurgy Dept.
National Research Corp.

Vacuum coatings are invading the industrial field. When they were introduced, application was primarily for decorative needs. But the coatings have been meeting a widening range of design requirements. And automatic machinery has moved in to speed up the process and lower costs—materials are coated not only in batches, but can now come off a continuous production line.

Industry has been finding the vacuum deposits superior to electrolytic and hot-dipped coatings for giving:

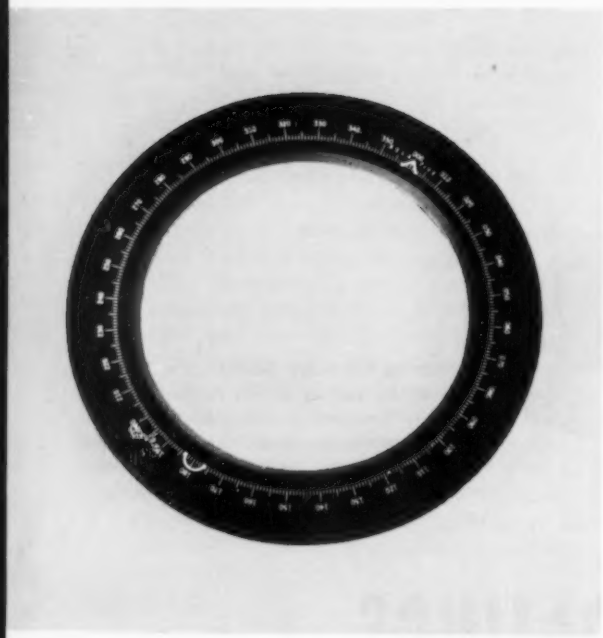
- Economical corrosion resistance to sheet steel.
- Miniaturization of electrical components.
- Special properties to semiconductors.

Vacuum coating is also useful in supplying:

- Chemically active surfaces.
- Metal-lubricating films.
- Decorative effect.

Continuous production has cut the cost of aluminized sheet steel sufficiently to make it competitive with tin plate. Machinery moves the steel from atmosphere to vacuum, applies aluminum, and returns it to atmosphere. The thin coatings measure 10 to 15 microin. and their corrosion resistance seems to exceed that of electroplated tin of same thickness. The lightness of aluminum gives additional savings in materials—1 lb of aluminum can cover 4,000 sq ft. There is no need for thermal treatment to seal pin holes as with tin plate.

The industrial field for vacuum-deposited films has increased with advances in solid-state semiconductors. For rectifiers and transistors, the coating method of creating needed films on various types of surfaces is being increasingly used. Miniaturization is another stimulus because the thin films occupy minimum space. An experimental electrical capacitor with layered coatings of conducting aluminum a few microin thick



Selective coating . . .
was given this dial after photographic masking. Limiting metal deposit to scale readings improves accuracy through better readability.

Quick Glance at the Process

In vacuum metallizing, the coating material is vaporized by heating, then condensed on a cool surface. Besides all pure metals, some alloys, metal compounds, and the more stable organics can be deposited. In general, metals with high vaporizing temperatures, such as wolfram and molybdenum, are uneconomical. Alloys with constituents having similar vapor pressures can be deposited as if they were pure metals, but alloys with wide differences of vapor pressure must be evaporated simultaneously from multiple sources.

Vacuum required in the coating chamber is below 0.5 microns absolute. This vacuum serves three purposes: prevents oxidation and combustion, lowers vaporization temperature, and promotes traverse of coating molecules. Coating may be followed by coloring, conversion treatments, and protective coatings.

Since metallizing is based on simple evaporation and condensation, it gets around most limitations of the other commercial processes for metal deposition. There is no electrolytic action, no hydrogen embrittlement as in electroplating, and no forming of intermetallics as in hot-dipping. The coating remains cool and does not require rigorous precleaning for deposition. This allows using heat-sensitive materials for the base, also those that are too fragile to undergo treatment with cleaning solvents, acids, alkalis or gases.

deposited on insulating cellulose acetate film, occupies half the space usually needed. Mylar vacuum-coated with aluminum, now used for capacitors, has already given 40% size reduction.

Base Materials

Ferrous and nonferrous metals can be coated in form of castings, forgings, stampings and extrusions. Strip and plate are particularly suited for continuous operation.

Many plastics take coating. These include melamines, acrylics, styrenes, acetates, butyrates, polyesters, polyvinyl chloride, polyethylene and fluorinated hydrocarbons. They are coated in molded, hot-formed, extruded, cast and film forms.

Minerals such as quartz and mica, also glass and ceramics, are among the most easily coated materials, especially when the surface is glazed and smooth.

Fibrous materials—wood, textiles, paper—also can be coated. Usually, the surface of these materials must be sealed before coating. With textiles and paper, sealers should prevent gassing without reducing flexibility to any noticeable extent.

Coating Properties

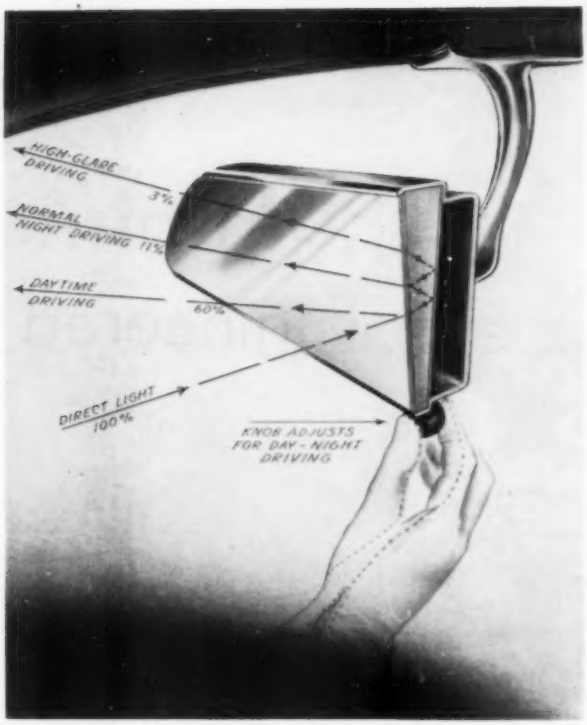
Thickness of coatings deposited is typically from 1 to 400 microin. For optical and decorative purposes, a thickness of 2 to 3 microin. is sufficient. Vacuum-deposited coatings follow the minute variations of a surface, add imperceptible weight, are extremely uniform in thickness, and do not alter tactile qualities of the base—metallized textiles feel no different than uncoated samples.

Ductility of base material is unchanged because of the extreme thinness of the coating. The low temperature of the process does not give any chemical reaction that produces brittle compounds. Sheet steel, aluminized by this method, can be subjected to the same rigorous drawing as with electrolytic tin plate.

Throwing power places limitations on size, shape and placement of parts within the coating chamber. Coating varies inversely as the square of the distance from the source. Where base surface is not at right angle to the source, thickness of coating varies as the cosine of angle between the perpendicular and the actual path. This means blind holes deeper than 1½ times their dia cannot be uniformly coated; objects that need coating on more than one side must be coated by multiple sources, or by rotating the parts during coating.

Masking in a discrete pattern can be applied by photography, silk screen, or stencil. Where dimensions of the pattern are not critical, reusable stencils can be used.

Corrosion protection of vacuum-metallized coating is less than with the thicker hot-dip or electrolytic coatings of the same material. However, for limited short-term protection, it can be provided at min cost because deposits are uniform and thin. Aluminum and more noble metals are preferred because these furnish



Choice of reflectance . . .
goes with this automobile rear-view mirror, vacuum coated with three layers of metal salts.

barrier protection while sacrificial coatings such as zinc are short-lived. When organic topcoats are used for corrosion protection, the decorative metal coat can be thinner.

Diffusion of vacuum coatings into the base metal by heat can improve appearance and increase adhesion. These diffused coatings have a graded composition which varies from the outside to the base-metal surface.

Abrasion of the coatings should be avoided because of their extreme thinness. Even with hard materials, a superficial scratch will penetrate the surface. Soft metals such as selenium offer a poor surface. Chromium gives a coating with much better abrasion properties.

Secondary protection can be given by an overlay of silicon monoxide which oxidizes to form a protective quartz film. In some cases, a compound coating may be deposited by coating with the elemental metal and treating it chemically. Hard, transparent titanium oxide gives coats for protecting softer undercoats such as magnesium fluoride, used to reduce surface reflection on lenses.

Organic coatings are the most widely used protective coating for vacuum-metallized parts. Solvent-containing plastics and porous wooden parts are precoated to seal porous surfaces; to prevent degassing of solvents and plasticizers; and to form a smooth surface which eliminates need for buffing. Organic topcoats applied by dip, spray or flow-coating protect the metal from abrasion and corrosion. Metallic colors other than aluminum are achieved by dye-tinting the transparent overcoat. Sealers used depend upon base material and type of service. Lacquers are used on thermoplastics because they harden without baking, but enamels, which harden by solvent evaporation, with subsequent oxidation or polymerization, are used with thermosets where baking can be employed.

Limitations

Contaminants volatile at coating pressures flash off from the source when heated, giving molecules which interfere with coating; and low-vapor-pressure adulterants such as oxides and carbides usually remain on the base metal to decrease adhesion. Unclean surfaces give poorly adhering coatings. For example, molded plastic parts made with lubricants to facilitate release from the mold give coatings that will rub off; but a copper coating applied on a properly cleaned paper laminate adheres with a tenacity stronger than the base.

Dryness is especially important because 1 cu in. of water will expand in a vacuum to several hundred cu ft of vapor which must be pumped out. Even then, enough vapor remains to collide with impinging coating molecules, and give poor adhesion and discolored coatings.

Cost Considerations

Depositing a metal film by thermal evaporation in vacuum is simple and inexpensive. In industrial batch-type equipment, including cleaning, racking, loading, inspection and preparing for shipment, the cost is between 0.01 to 0.02¢ per sq in. for small parts. Where the part is coated for decorative purposes, and protected from corrosion by organic base and topcoats, the cost is 0.1 to 0.2¢ per sq in. These figures include only direct labor, materials and operating supplies. Frequently, metallizing saves costs by reducing steps in manufacturing.

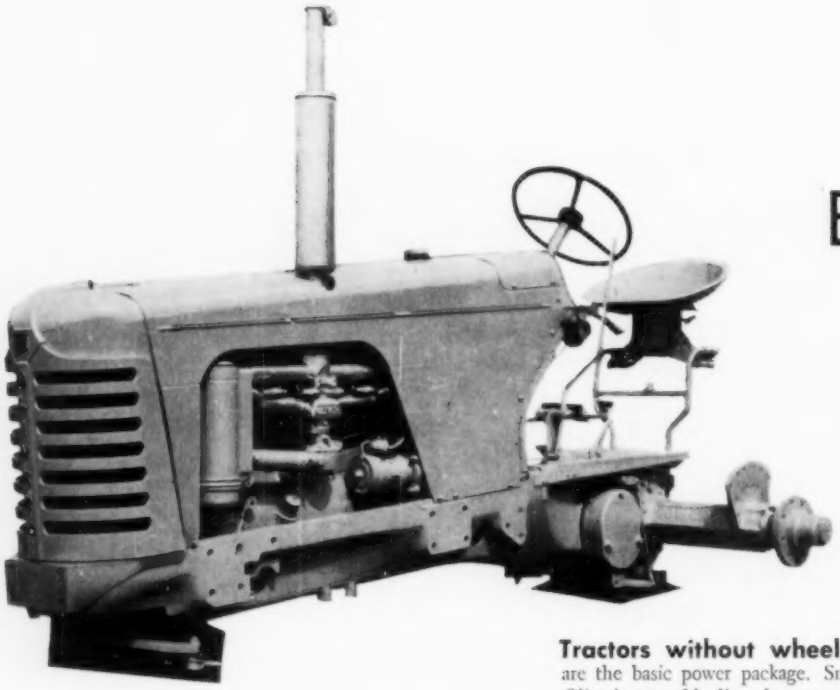
Continuous metallizing of sheet and strip is even lower in cost: Mylar sheet plastic can be coated with aluminum for from 4 to 5¢ per sq yd; paper which is metallized for the appearance, light and heat reflectance of metal foil is coated for about 1¢ per sq yd.

EDITOR'S NOTE: For comparison of the vacuum method with conventional coating processes, see: "Hot-dipped Aluminum Coatings," Oct 28 '57, p 57; and "Plated Finishes—the Choice Widens," Oct 28 '57, p 81.

Additional information on types, properties and uses for vacuum-coated plastic films is given in "Metallized Plastic Films," Aug '55, p 182.

DESIGN FEATURES

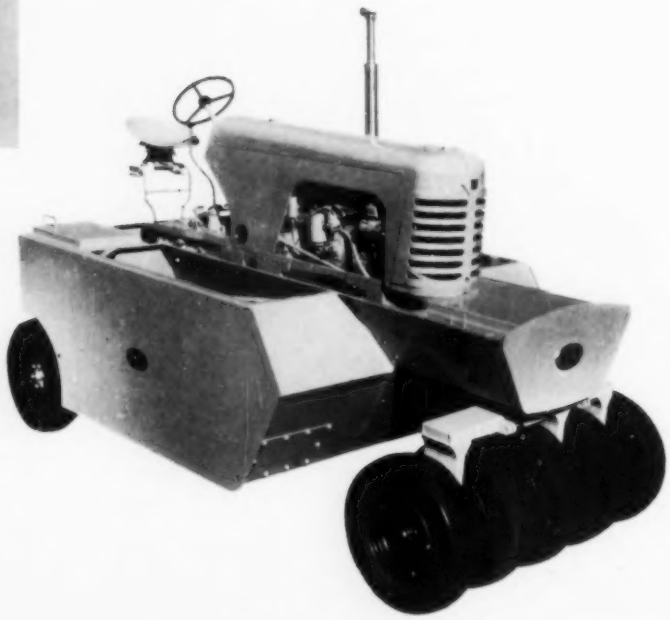
Engine Engineered



Tractors without wheels . . .
are the basic power package. Small orders come directly off Oliver's assembly line; larger quantities are scheduled as separate production runs. The assembly includes engine, clutch, transmission, differential, rear axle and hubs, brakes, steering gear and controls; it can be installed as the final assembly operation on any mobile equipment. Both gasoline and diesel engines are supplied in three horsepower ratings. Special transmissions, power steering and power take-offs are optional extras. Typical packages cost $1100 to $2900.

POWER-PAK SPECIFICATIONS

Model	Fuel	Hp	Cyl	Displ	Rpm	Torque
66	Gas or Diesel	35	4	144 in.^{3}	2000	110 lb-ft
77		46	6	216 in.^{3}	1600	166 lb-ft
88		58	6	265 in.^{3}	1600	204 lb-ft



Idea was born . . .
while selecting a drive for the Tampo Manufacturing Co.'s self-propelled, pneumatic-tired rollers. The package included hydraulically operated reversing clutches, a torque converter and power steering. A single lever controls reversing clutch and throttle setting. Roller can work forward or reverse at 0 to 13 mph and travel on the road at 22 mph. A 1:1-chain drive connects the power-package drive axle and the rear wheels. The largest engine is used for this application.

Needed;
Power Package Bought

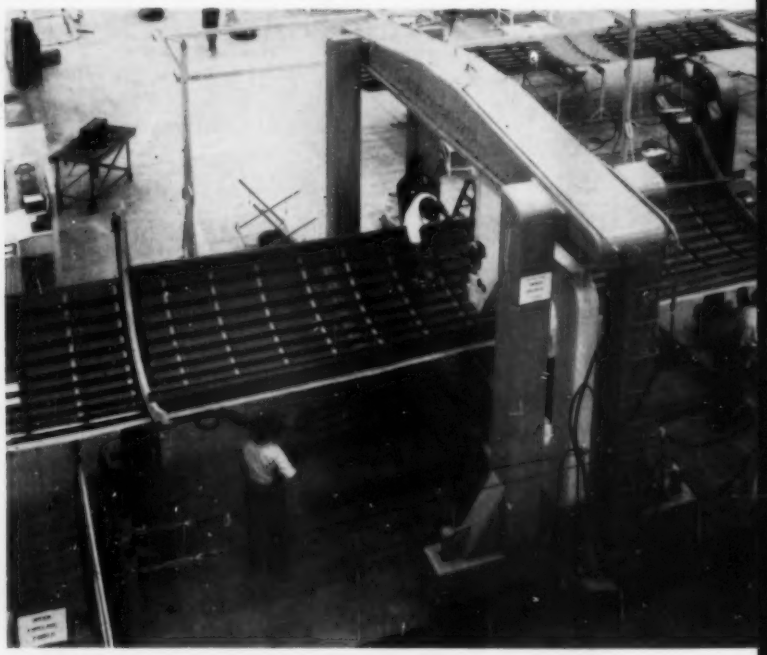
A mobile-equipment maker was looking for an engine. The sales engineer from Oliver Corp., Chicago, realized that actually the entire drive was needed, because clutch, transmission, differential and axles had to match the engine's characteristics and be assembled in a common frame. Savings are inherent in a combination. So-o-o-o the client didn't buy an engine; he bought a drive package and Oliver had a new product, the Power-Pak.

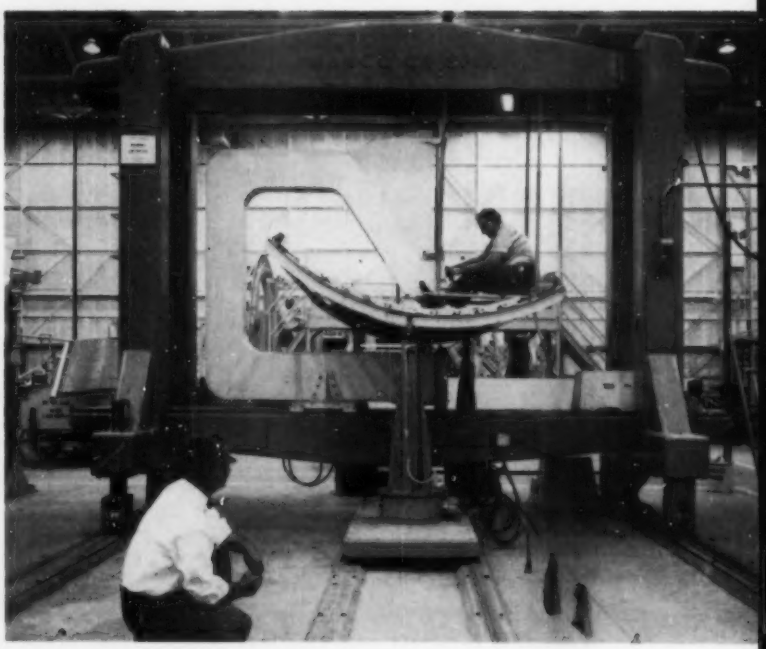
Built around basic tractor, . . .
this Sky-Hy lift positions 3000-lb. loads to heights of 25 ft. Operator, steering gear and controls for hydraulic lifting mechanism are on side extension of tractor's frame. The lift, designed by Lull Engineering Co., St. Paul, Minn., is available also as a crane and with attachments for handling lumber or bulk materials. An automatic leveling device keeps forks at the same angle throughout lifting cycle. This machine uses the 46-hp package.

Overhanging engine on broom . . .
is supported by tierods that transmit load to the front boom. Power package is always supported at rear axle and at a point under the engine to prevent deflections that might misalign the drive. The hydraulically controlled broom, also designed by Lull, can rotate in either direction and is aligned with the boom for road travel at 14 mph. The machine sweeps in either direction. Power package supplies motive power for drive wheel and hydraulic power for broom.

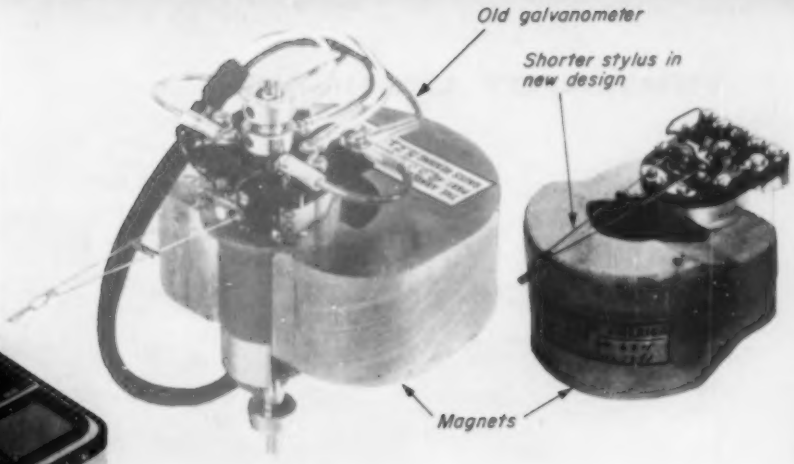
The riveter now comes to the work in this gantry machine developed by Douglas Aircraft Co. for wing and fuselage panels of the DC-8 jetliner. Results: faster riveting to closer tolerances and savings in assembly space. Design was originated by T. S. Crispin, tooling administrator at the Douglas Santa Monica div. and is manufactured under license by Manco Mfg. Co., Bradley, Ill.

Mountain Comes to Mohammed





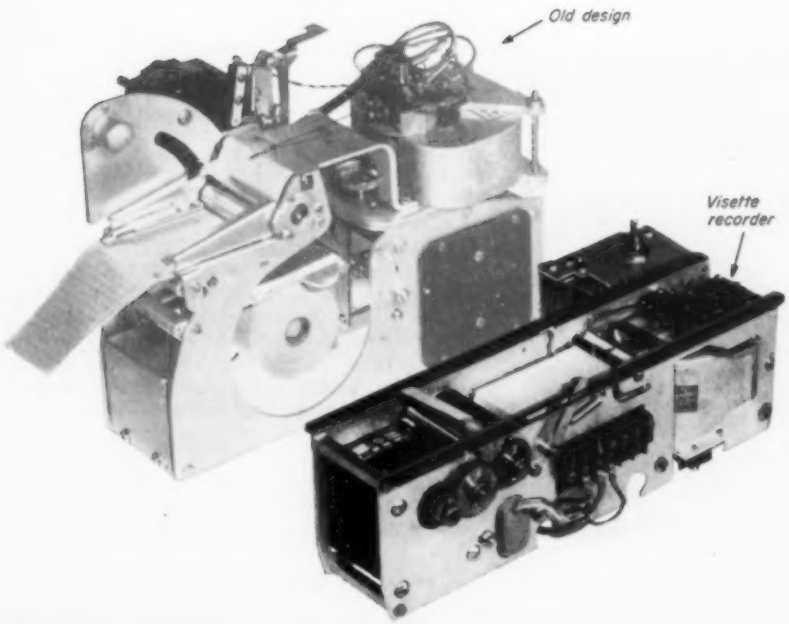
A yoke inside the gantry . . . carrying riveting and shaving tools, swings freely over the panel being riveted. It slides across the gantry for transverse positioning, and is carried along the panel when the gantry moves. Air motors jog it close to working area where operator does final positioning by hand. Riveting cycle is automatic. First, a pressure foot is raised to the work to squeeze it against rivet head. Next, a rivet gun upsets the rivet, and retracts. Finally, a shaving mechanism removes excess rivet metal. Wing or fuselage panel is held on a 3-point fixture containing a position-sensing device. Panel is automatically turned to keep riveter normal to working surface. Yoke is worked down one side of the stationary panel, swung around the end, and worked back up the other side. Scatter patterns can be riveted without intricate programming, making last-minute modifications less costly.



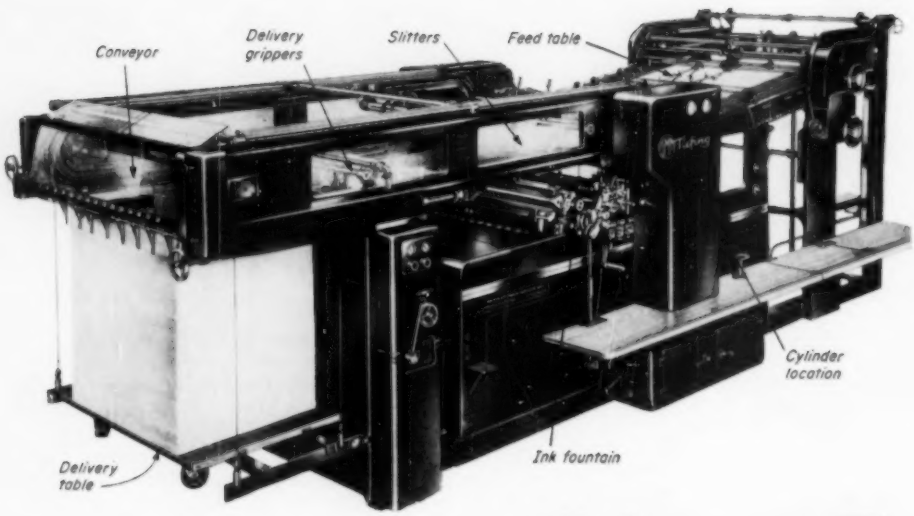
Narrower chart . . .
has 40 divisions $\frac{1}{32}$ in. wide, instead of the 50 of 1-mm width on previous charts, and requires 40% less space. Useful voltage records are only 20% smaller, however, because largest heart signals seldom exceed 40 divisions (4 mv). The narrower chart led to shortening the galvanometer stylus by 25%, and still retained a half-chart-deflection time of 0.007 sec. Lower inertia of the shorter stylus ($I_s = I_1 + Md^2$) amplified these gains by reducing the driving power from 2.2 to 0.72 w. Galvanometer weight was cut from 4.50 to 2.25 lb. The Visette was developed under the guidance of Dr. Arthur Miller, director of research.

Cardiograph Goes to Patient

The first truly portable electrocardiograph now allows doctors to make accurate heart-voltage records in homes and hospital wards. Made by the Sanborn Co., Waltham, Mass., the model 300 Visette weighs 18 lb and was designed to supplement present office instruments. Compactness results from both reduced chart width and transistor amplifiers that drive a direct-writing galvanometer.

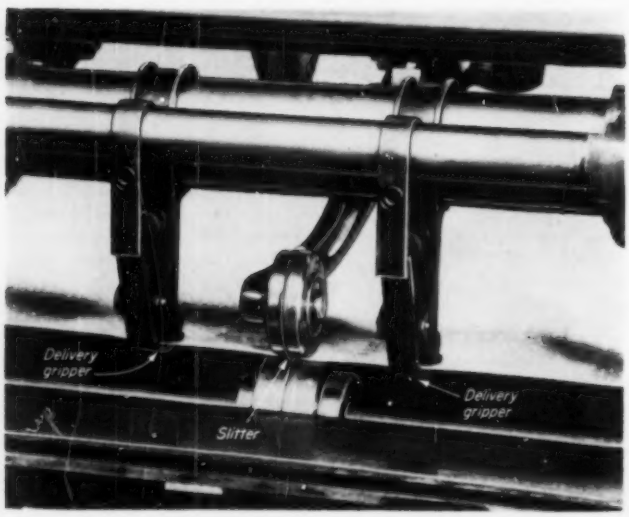


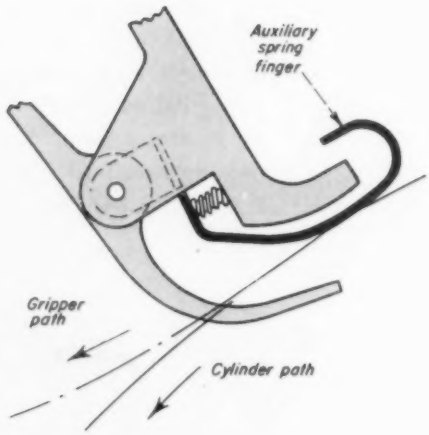
Recorder assembly is smaller, . . .
lighter and requires less power to drive the chart. Chart roll is 1¼ in. wide, 100 ft long and drops into the recorder from the top. In previous design, chart roll was inserted from the side and threaded up through the writing mechanism. Trace is made on the heat-sensitive paper by heated stylus. Paper speed is still 25 mm per sec. Only 3 vacuum tubes are in the portable instrument, the other control elements are transistors and germanium diodes. Placing amplifier components on plug-in printed circuits helped reduce size and simplify servicing. The new Visette is 11 x 9½ x 5 in.; previous model was 15 x 11 x 9½ in. and weighed 36 lb.



Gripper Fingers Control Paper

In a flatbed letter press made by Grafiska Maskin Aktiebolaget, Trollhaetan, Sweden, auxiliary spring fingers control the transfer of printed sheets from cylinder to delivery conveyor. Careful design of gripping mechanisms, which feed paper sheets to cylinder and remove them at end of printing stroke, enables press to make up to 4000 impressions per hr while holding register within 0.001 in.





Grippers hold paper . . . at all times for positive register control. One set accelerates sheets from the feed table to printing cylinder. These are opened, closed and oscillated by cams synchronized with cylinder rotation. A second set of fingers recessed in the cylinder grip the paper during impression. Auxiliary spring fingers clamp the sheet against the cylinder while control is transferred to final set of grippers attached to delivery conveyor. These grippers are operated by a rail cam as the conveyor reciprocates between cylinder and delivery table. A slitting roll, under the delivery gripper, supports and cuts the sheets as they leave the cylinder.

LINKAGES GAIN ON CAMS

New German method applies the simplicity of cam diagrams to design of four-bar linkages

	ADVANTAGES	LIMITATIONS
CAMS	Easily designed to give complicated motion Can be made small and compact	Subjected to high contact stresses Subjected to excessive vibrations at high speeds Follower must be constrained to follow contour by spring which raises stress or by slot which causes backlash High accuracy of contour expensive and difficult to obtain
LINKAGES	Slight inaccuracies in link lengths have little effect on output motion Tolerance on location of pivot points easily maintained	Difficulty of analyzing linkage to achieve a specific motion Inertia of links causes dynamic forces at high speeds

Germany is now swinging toward four-bar linkages—in preference to cams—for translating motion in high-speed automatic machines and computers. The trend arises from a new method that makes it easier to employ the advantages of linkages. Specifying their dimensions has been a mathematical exercise—far more difficult than designing cam contours. But now, the graphical method illustrated on this page* gives linkage specifications with no more labor involved than matching curves.

With both linkage and cam, an input that rotates with constant velocity will produce an oscillating output characterized by a specific pattern of motion. In cam design, the desired relationship between input and output is customarily plotted on rectangular coordinates. From this "cam diagram," it is simple to design the profile graphically.

It is this same diagram which has been borrowed for linkage design by the professional kinematic committee of the VDI (German Society of Engineers). At cost of considerable labor, it has been compiling a series of charts showing families of curves for various link proportions. These are theoretical linkage curves obtained by varying one link while keeping the other two constant.

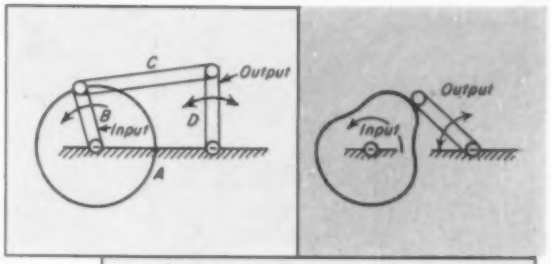
To find the correct linkage length that will give the motion specified by a cam, the cam diagram is redrawn on transparent paper to the same scale as the theoretical linkage curves and moved over the curves until one is found that matches closely. This gives the desired ratio of the links—a fairly accurate approximation.

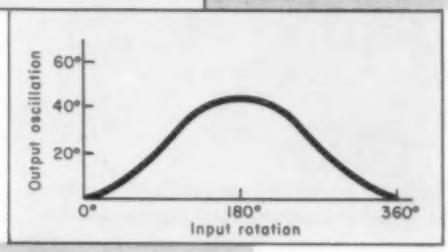
There is a family of curves for each ratio of B/C and C/A. The method is especially useful when only one portion of a cam curve is called for in a device. Accurate interpolation between curves, when necessary, is a simple procedure.

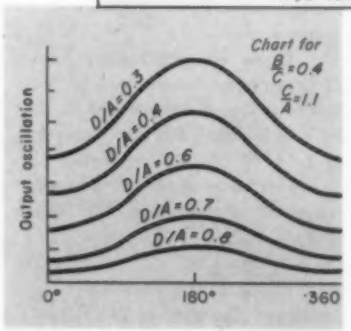
*Based on a technique reported in "Tables of Curves for the Design of Four Bar Linkages," by Gerd Kiper, VDIZ, Vol. 99 No. 24, Aug 21, 1957, Bongardstrasse 3, Dusseldorf, Germany. Working charts for a wide range of link ratios are being prepared by VDI; announcements of their availability will be made later.

How Cam Motion Is Translated to a Linkage

Basic similarity . . .
of four-bar linkage (left) and cam (right). Both convert constant rotary motion into oscillating motion.

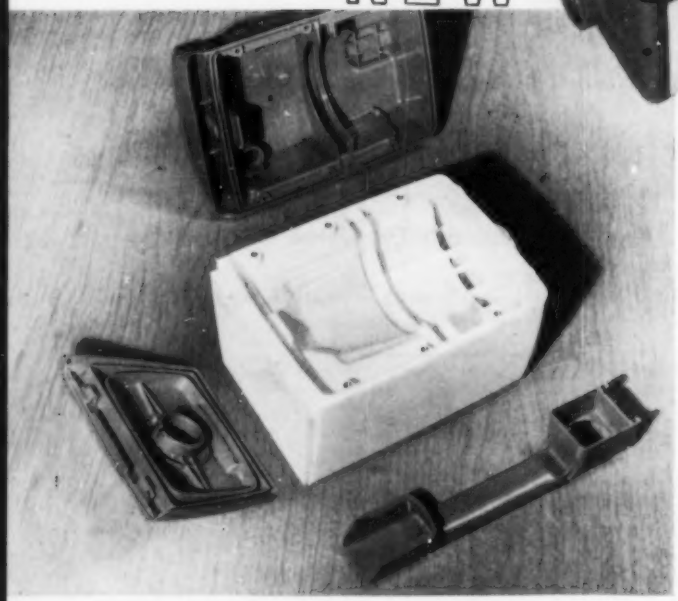






▲ **Starting point . . .** of German method is conventional cam diagram. It specifies desired output oscillation in terms of input angle. Diagram is redrawn, to appropriate scale, on transparent paper and then moved over . . .

. . . Family of linkage curves . . .
until one is found that corresponds, and correct values for link ratios are then read off. Shown here is one similar to the series of charts prepared by the VDI. Each curve family was made by keeping links B and C constant while varying D.



NEW NYLON FROM FRANCE

- TOUGH
- MOISTURE-RESISTANT
- ELECTRICALLY STABLE
- EASILY COLORED
- NOW AVAILABLE HERE

J. FOUQUE

Development Engineer, Organico, Paris, France

A new French polyamide, nylon-11 (or Rilsan as it is called in France) now available here at competitive prices, is rated superior to established nylons in three main areas:

• Water absorption. Water absorbed after 14-day immersion is only 1.6%, compared with 10.2% for nylon-6/6. Weight increase in 3-hr boiling water immersion is 2%, compared with 8.6% for nylon-6/6.

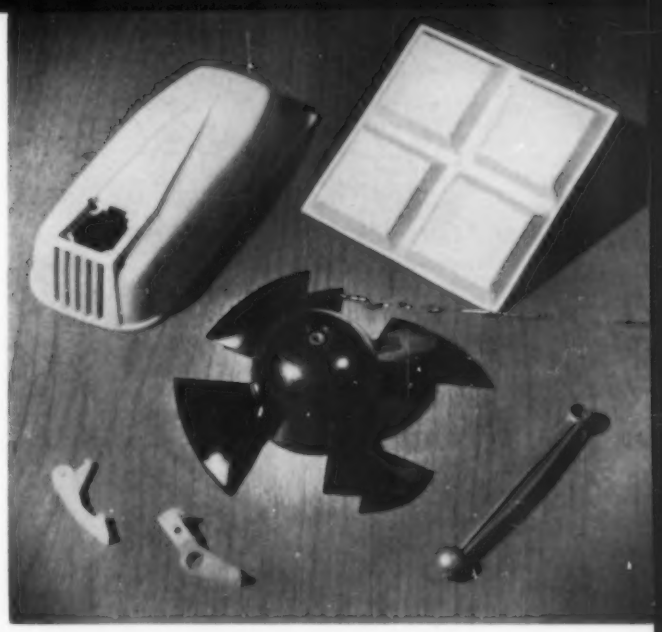
• Shock resistance. Ease of plasticizing gives formulations with high impact strength, in some cases about double the strength of unplasticized. This makes the plastic valuable in parts subject to dropping, like electric shavers and food mixers.

• Thermal resistance. Spread between fusion temperature and degradation temperature has been increased as a result of a lower melting point, so that flame-gun or fluidized coatings are more easily applied to metal parts without damage to the material. Also now possible are large precision moldings that normally require more time in the mold.

Water absorption has been the chief nemesis of polyamides because close-tolerance parts like gears, cams, sleeve bearings, and pump impellers swell in water or moist atmospheres. Amount of swelling is predictable for most nylons, but high-swelling formulations have been avoided where precise running clearances must be kept for all levels of moisture—as in water meters, washing machines, computers, business machines and the like. Derived from castor oil instead of petroleum or coal, nylon-11 shows slight change in dimensions—about one-fifth that of nylon 6/6 for prolonged exposure. Swelling characteristics compared to other nylons for various degrees of water immersion are shown on page 78.

Electrical properties are stable, too, thanks to low water absorption, and resemble those of other polyamides in the dry state. Nylon-11 is an excellent insulator at low and medium frequencies and at low and medium voltages, making it ideal for moldings, extrusions and coatings in electrical applications like radios,

◂ **Injection-molded nylon-11 . . .**
supports blower, channels air in small vacuum cleaner designed for easy cleaning.



High impact resistance . . .
and toughness. Top, from left: food-mixer body, embedded highway markers. Center: air-conditioner fan. Bottom: refrigerator door latch, record changer bell-crank, auto throttle push-rod.

Low water absorption . . .
or chemical resistance. Top, from left: wax-sprayer compressor fan, roller-bearing retainer. Bottom: sparkplug cover, two-piece carburetor float.

auto electrical systems, telephone parts and communication cable.

Toughness of nylon-11 along with a widened operating temperature range of 280 F to −65 F, permits application where impact loads might occur–such as in domestic vacuum cleaners, auto dashboards, fan blades and gears.

Upper temperature limit for continuous operation in air is 212 F, same as for other nylons; but it can withstand short-time exposure to 280 F if followed by periods at lower temperature to dissipate accumulated heat. High specific heat allows absorbing large heat input as well as considerable intermittant localized heating.

Chemical activity is low, particularly with alkalis and most petroleum solvents, oils and greases. Resistance to organic acids, mineral acids, and dilute oxidizing agents exceeds that of other nylons.

Many grades, with different degrees of hardness and flexibility, are made possible by polymerization control and adding pigment and plasticizers (see table, page 79). The first seven grades shown can be made especially resistant to light-discoloration and fungus-attack.

(*continued on next page*)

Large molding . . .
forms instrument cowl and dashboard trim on Citroen DS-19 four-door sedan, gives good dimensional stability, impact resistance, smooth surface, and color retention.

DESIGN OF MOLDED PARTS

Mold shrinkage is a function of shape and especially thickness, as well as temperature, pressure and length of the mold cycle. The same molds are used as for other thermoplastics. Higher fluidity of nylon-11 causes it to flow into mold imperfections–and also helps give good surface detail. Sprues and runners should be circular and large to prevent solidification. All normal types of gating are satisfactory, including pin-point gating. Steel molds with high surface finish are best.

Thermal stabilization, or stress-relief, is required only if molded parts operate above 150 F in moisture-saturated air or in hot liquids. If no treatment is given, progressive shrinkage occurs under these conditions, but is less for nylon-11 than for other polyamides. Parts are stabilized by soaking in warm mineral oil for ½ hr, at a bath temperature slightly above the working temperature of the part. Parts are dried for one hr at about 190 F, followed by slow cooling.

GEAR DESIGN

Nylon-11 gears successfully transmit low torque at moderate speeds in devices like electric shavers, water meters, cash registers, and calculating machines. As with other nylons, frictional heat must be limited because low conductivity and high specific heat tend to concentrate heating at friction points. Coefficient of friction between nylon-11 and steel is between 0.04 and 0.20, depending on test conditions. These values can be appreciably lowered by water or mineral-oil lubrication.

High compressive stresses result in tooth wear, but can be minimized by avoiding disengaging drag between teeth. Max allowable tooth load depends on peripheral speed of the gear. Clearance for thermal expansion must be allowed, or gears will seize and fuse. Although this creates some cold play, impact resistance of nylon-11 is good, and shocks in start-up and vibration during operation are absorbed easily and quietly for most applications.

EDITOR'S NOTE: Coming soon is an article that will discuss performance and design of metal sleeve bearings coated with nylon-11. Other recent articles on various aspects of nylon part design:

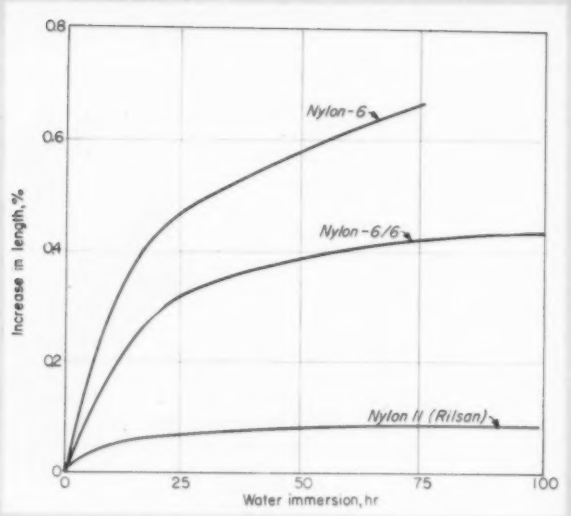
"Plastic Extrusions," Nov 25, '57, shows how to design complex parts for fabrication from simple extruded shapes.

"How to Design Cost Out of Plastic Parts," Oct 14, '57, p 77, covers costly requirements that aren't always necessary. Charts classify materials and processes for ready reference.

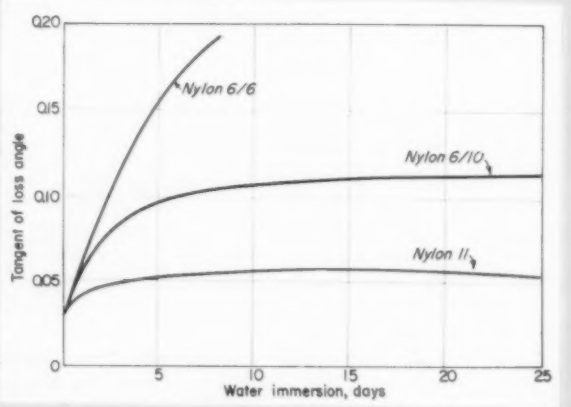
"Synthetic Fiber Felts," July '57, p 178, presents data on four types useful when high strength, good corrosion resistance, and low compression set are needed.

"Fluidized Plastic Coatings," Jan '57, p 140, discusses a powder-dip process for corrosion-resistant coatings on intricate metal parts.

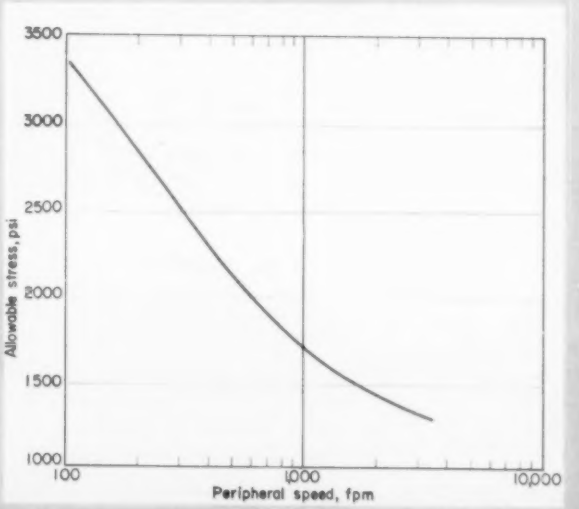
"Tough, Rigid Thermoplastics," Nov '56, p 167, contains a selector chart for 28 high-impact plastics.

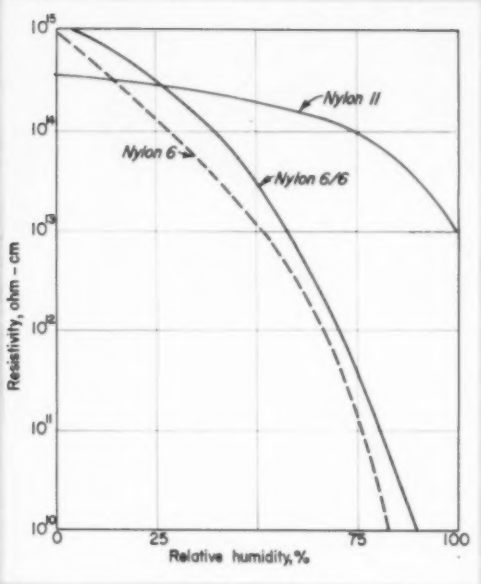


Swelling in water . . . ▲
is low after 100-hr water immersion, compared to other nylon grades. Specimens were 3 mm thick.

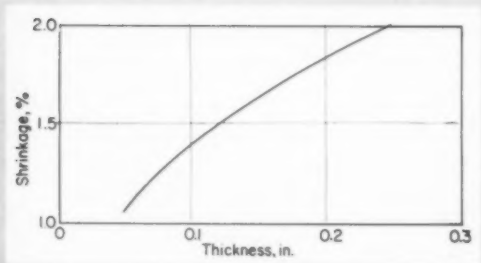


Dissipation factor . . . ▲
is always influenced by moisture, but prolonged water immersion affects nylon-11 least: at 1000-v, 1000-cycle current.





Arc resistance . . . ▲
stays high for nylon-11 over a wide range of relative humidity.



Percent shrinkage . . . ▲
on molded parts is highly influenced by section thickness. Longer pressure cycles cut shrinkage on precision parts, but boost part cost.

◀ **Gear-tooth loading . . .**
for nylon-11 gears running against steel must be reduced with increasing peripheral velocity.

PHYSICAL AND MECHANICAL PROPERTIES

Specific gravity	1.04
Melting point, °F	367
Specific heat, cal/gm/°C	0.50
Thermal conductivity, btu/hr/sq ft/°F per ft	0.465
Heat of fusion, btu/lb	20
Coefficient of expansion, per °C	11×10^{-4}
Ultimate tensile strength, psi	8,000
Elongation to break, %	60–180
Elastic elongation, %	10
Impact strength, ft-lb/sq in	250–300
Elastic modulus, psi	16–20,000
Compressive strength, psi	12–15,000

ELECTRICAL PROPERTIES

	dry	80%RH	100%RH
Volume resistivity, ohm-cm (at 20°C and 1000 V)	6×10^{1}	2×10^{14}	10^{13}
Dielectric constant (at 20°C)	3.7	3.9	3.9
Dielectric strength, kv/mm (at 20°C)	25.0	24.0	24.0
Dielectric dissipation, tan loss angle (at 1000 v, 1000 cycles)	0.02	0.03	0.05

BASIC GRADES AND APPLICATIONS OF NYLON-11

GRADE	COLORS	PROCESS	SPECIAL PROPERTIES	APPLICATIONS
BMn	Translucent (natural); all colors	Injection molding	Dielectric strength, tensile strength, chemical inertness	Electrical insulation, parts for sterilization
Bmn P20	Translucent (natural); all colors	Molding	Between BMn and BMn P40	Flexible parts
Bmn P40	Translucent (natural); all colors	Molding	Flexibility, impact resistance, elongation	Unbreakable parts
BMn G8	Gray or black	Molding	Hardness, wear-resistance	Gears, bearings
BEC	Translucent (natural); all colors	Extrusion	Dielectric strength, tensile strength, chemical inertness	Primary wire insulation
BEC P20	Translucent (natural); all colors	Extrusion	Between BEC and BEC P40	Cables, tubing
BEC P40	Translucent (natural); all colors	Extrusion	Flexibility, impact and abrasion resistance	Secondary cable sheathing, flexible tubing
BES N	Translucent or transparent	Extrusion	High viscosity, tensile strength, chemical inertness, dielectric strength	Industrial tube and sheet
BES A	Translucent or transparent	Extrusion	High Viscosity, tensile strength, chemical inertness	Tube and sheet for food processing and packaging
Fine Powder	Translucent or transparent	Flame spray, immersion	Abrasion resistance, chemical inertness	Protective coating for metal parts

Design for Pay Dirt

Bulldozers, cranes, power shovels are impressive, but what about the components needed to make them bigger and better? We asked the question and here are the answers from the nation's leading builders of earth-moving equipment.

Heavy construction equipment, an industry whose gross has swollen into billions of dollars since World War II, is relying on new design to keep afloat in a tide of rising labor costs, narrowing profit margins and sharpening competition.

The industry's needs—resulting in the doubling, even tripling, of research and development expenditures—are for larger-capacity earth-movers capable of operating at higher speeds and lower costs. Much of the responsibility for meeting these needs rests on manufacturers of components going into the machines.

For information on design progress, PRODUCT ENGINEERING questionaired a sizeable segment of the 350 major equipment-builders—companies who make the bulldozers and scrapers, the tractors and compactors, the crane shovels, graders, ditchers, pavers, spreaders, trucks and other related items (see accompanying chart).

To a man, the builders cited increased wages and equipment costs as main reasons for demands by contractors for equipment with greater capacity. One company spokesman put it this way: "Our users need more horsepower, more capacity, more ruggedness to endure round-the-clock operations, to produce more yardage at lower cost and beat the profit squeeze. Earth-moving bid prices have remained fairly constant while labor, operating and equipment costs have jumped sharply."

A shortage of experienced machinery operators has forced design to figure out easier-to-operate methods; controls that last longer despite rough treatment; transmissions, largely hydraulic, that will not only make shifting simpler but protect equipment from damage resulting from mishandling. One manufacturer's capsuled opinion—"The trend has been to torque converters to protect equipment from the operator."

Of additional significance to future design in this industry is the $33-billion Federal Road Building Program which between now and 1975 will require $7.3 billion worth of machinery. Production output of the industry is expected to increase by 45% during the first three years of the program.

Not that the industry can't meet the program's needs with existing equipment—after all, this is just another road-building assignment, albeit a mammoth one. Where significance lies is the fact that such a prolonged project enables equipment makers and their customers to apply new design approaches that would be prohibitive during short-term projects.

• Here's What They Say . . .

(Where no company name follows a statement, that company chose not to be identified.)

Affirming the trend to larger-capacity equipment, industry spokesmen declare:

"We need larger payloads for each cycle of operation for our cranes"—Bay City Shovels, Inc.

"Customers are demanding it. They want tractors and graders that operate at higher speeds and at lower unit-of-measure costs"—International Harvester.

"This is true, especially with trucks and mixers"—Construction Machine Co.

"Bigger loading shovels call for larger haulage units to keep operations in balance, especially on big projects"—Euclid Div., GM.

"The larger the stone crusher we make, the less blasting and quarry operation"—Eagle Crusher Co.

Other companies gave similar reactions. Here are samplings:

"New designs are required because of new construction methods and demands for increased capacity."

By 2's . . .
Although the trend has been to larger equipment, Euclid Div., GM, is staying with low horsepower engines—but is using two of them, as shown here. At left is the TC-12 twin power crawler tractor. Two GM diesels, deliver a total of 436 hp. Independent track drives, through Allison torque converters, give unusual maneuverability.

The R-50 rear dump truck, center, with a 50-ton carrying capacity, is also twin powered with two Cummins 300-hp diesels. Each engine drives one of the rear axles through a torque converter. Top speed with a 50-ton load is 32 mph.

The TS-24 Twin Power scraper, right, has separate engines in the tractor and behind the scraper bowl driving through torque converters with final planetary gear reductions in each wheel. A 300-hp engine drives the front wheels, and a 218-hp engine the rear wheels, giving the unit larger self-loading capacity.

"There is a definite trend in this direction, but we are running into weight limitations."

"Air compressors have to be larger since the big construction jobs in many cases require more air than a 600-cu ft machine can deliver. Contractors also want larger capacities in portable models such as in the 900-cu ft range."

A qualifying viewpoint was taken by another manufacturer: "Equipment size may be at its upper limit, and the cost of equipment may be causing some people to take a look at the more effective use of medium-size units, of which some are being designed for greater production, that will let them stay in the medium cost range."

• The Details That Count

In listing outstanding design features being applied to their products, manufacturers had this to say:

"The trend is to more power and wider tracks for our crawler tractors."

"We find rubber-tired tractors are fast making inroads on functions previously the sole province of the crawlers."

"The more power steering we can apply, the better the maneuverability for the operators, who quite frequently are inexperienced."

"Simplified controls are essential for the reduction of operator fatigue."

"Turbo-charged diesels provide more efficient operation."

"Continuing problem is how to more effectively mount attachments to the utility tractor. Already front-end loader and back hoe are attached, but standardized production is required."

"We are trying to improve hydraulic systems for

Quick Glance at Earth-Moving Facts

While costs of materials, labor and construction equipment have risen more than 22% since 1952, over-all cost of highway building has increased less than 3%, thanks to advanced design.

Just 50 years ago, road building was 95% manpower and 5% equipment. Today, it's just the reverse and may soon be 1-99. . . . Recently a team of contractors with latest earth-moving equipment completed a 236-mile, 4-lane highway in one construction season of six months . . . Ten years ago it took 250 days to move 2½ million cu yd of earth; today it can be done in half the time and for less money.

Labor costs have risen, but so has rated horsepower. In 1935 the average wage was $1.09 per hr, and tractor hp was 95. Ten years ago average pay was $2.25 per hr, and tractor hp was 130. By 1955 it was $3.25 per hr, and 230 hp . . . To build 123 miles of 4-lane highway requires 1 million tons of bituminous concrete, 1.7 million tons of crushed stone, 6 million cu yd of gravel, 600,000 cu yd of concrete and 60,000 tons of steel.

In 1930 a mile of concrete could be laid for $30,000. Today it costs at least $1 million . . . The average piece of earth-moving equipment costs $100,000 . . . Using a labor force of a size commonly employed nine years ago, contractors with today's advanced equipment can get 66% more work done . . . According to industry sources, it costs about $30,000 to research and develop equipment that will make it possible to eliminate one human labor unit.

Caterpillar, giant of the industry with a 1956 gross intake of $696 million, will spend $600 million in next three years expanding plant capacity; it spent $1 million to research and develop the first diesel-powered tractor . . . Back in the 1930s, LeTourneau was first to put pneumatic tires on steel wheels of tractors and scrapers . . . Euclid Div. of GM, acquired by the automotive firm in 1953, pioneered twin-engined crawlers and scrapers.

The industry has been assured that roadbuilding will not play second fiddle to a missile project speedup. Completion of the 41,000-mile highway network is vital to national defense, Administration spokesmen aver.

However, prospects for completion of the program by 1969 have dimmed. Meanwhile, observers note a continuing lack of cooperation among state officials and municipal politicians . . . Under short-term conditions, it takes $1 worth of construction equipment to build $2.03 worth of road. With longer-term projects, like the federal program, the same equipment can build $3 worth of road.

What they can do: huge trucks rumble along with 15 to 20 cu yd of rock excavation . . . Self-powered scrapers scoop up and evenly distribute 20 cu yd of fill in one pass . . . Powerful 365-hp tractors with twin diesel engines push giant scrapers . . . Big shovels eat their way through hills; and at river banks, long diesel cranes, with 25-ton lift capacity, place beams for bridges.

our front-end shovels. Also to obtain better traction for rubber tires which we find are taking some of the play from crawler tractors."

"We need better metals, improved lubrication and sealed units."

"We seek larger buckets, clamshells and draglines for concrete"—Bay City Shovels, Inc.

"We're shifting to electric power when the bucket capacity exceeds five cu yd (used on larger projects) because downtime is minimized."

"Our parts-interchangeability program, started two years ago, is paying off. We save by stocking fewer parts, and gain sales by being able to make fast deliveries. There is no engineering waiting time"—Manning, Maxwell & Moore.

"Torque converter provides smoother, more efficient power. We are also continuing to seek closer manufacturing tolerances of better, longer-wearing metals for our rigs."

• Research on New-type Power Plants?

"For concrete spreading, and finishing machines for road construction, we're designing hydraulically operated machines, replacing the mechanically operated."

"Only where we can use more and more torque-converter power units"—Baldwin-Lima-Hamilton Corp.

"We emphasize using two-engines with completely separate torque converter drives. They permit us to double horsepower by using already accepted, and readily available, power plants"—Euclid Div., GM.

"With more and more attention focused on other-than-conventional fuels, we must necessarily investigate new power plants where we can."

"We increase horsepower as quickly as possible and wherever possible."

• Simplifying Design?

"Any place where a pound of metal can be replaced with a pound of dirt"—LeTourneau-Westinghouse Co.

"By standardizing as many parts as possible."

"Yes. For example, the injection capsule in our diesel fuel-injection system—great improvement over former method"—Caterpillar Tractor.

"Yes, to the extent we can expedite repair and maintenance"—M-R-S Mfg. Corp.

"Reducing air control units, at the same time making them more powerful to apply to smaller rigs, has been our aim. At the same time we've made the air controls directly responsible to the power-shovel operator's levers."

"We're designing for fewer and less complicated parts primarily to eliminate points of stress in highly stressed machines"—McKiernan-Terry Corp.

• Simplifying for Maintenance and Assembly?

"Using quickly removable major assemblies"—M-R-S Mfg. Corp.

"This one hits home for us since ours is the first line of construction machinery to have interchangeability of parts among tractor shovels, scrapers, and dozers"—Clark Equipment Co.

"Yes, as much as a third in our new dual-prime pump design"—Construction Machinery Co.

"Yes, and we're asking suppliers to do the same"—International Harvester.

Tires replace tracks . . .
more and more on tractor dozers as shown here by Clark Equipment Company's 375 hp Michigan 380 model. Rubber-tired dozers cannot completely replace the track type, for each will find its own particular use. Prospective users should consider the track type maintenance angle: in three years the total cost of a track type dozer is reinvested in maintenance. A good part of the business of track type equipment manufacturers is in spare parts. Other advantages for the tire-type vehicle: faster; does not have to be carried to the job site by truck.

"Reducing the different types of lubricating and transmission oils is also a step towards improving maintenance methods."

"We seek unit construction of components. For example, our barrel-type transmission which can be removed without disturbing engine or final drives"—Caterpillar.

"Yes, but primarily to reduce manufacturing costs. Maintenance is secondary to us, though not neglected"—Tampo Mfg. Co.

"This is a big service industry, therefore maintenance is a big factor in our sales approach. It is just as important as a performance feature."

"There is a need for quickly removable major assemblies."

• New Types of Operating Controls?

Backing hydraulics to the hilt, I. T. White, mgr Construction Equipment Sales for Warner & Swasey, has this to say:

"We are convinced that all excavating equipment up to and including one yard machines will eventually be completely operated and powered hydraulically. Warner & Swasey has pioneered in the field of hydraulically operated excavating equipment, marketing its Gradall right after the War. Our present line, including Gradall and Hopto units, ranges from ⅛ to ½ yard and throughout the full line, we have found that close attention to quality of cylinders, valves, manifolds and other hydraulic components is vital to high performance, low operating costs, and long machine life."

"Not to any great extent"—McKiernan Terry.

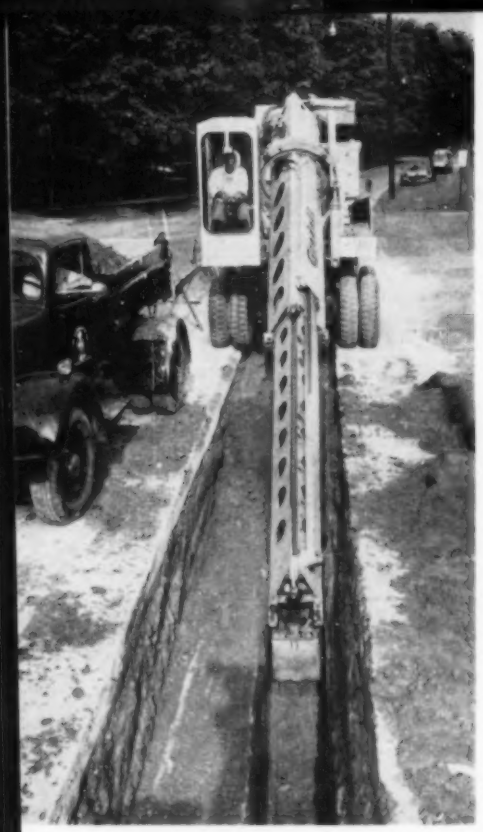
"Yes, especially steering and transmission"—Caterpillar.

"Yes. For instance, single-stick for operator"—American Tractor Corp.

"We need more refined electric controls for our cranes."

"We've reduced the number of pedals, buttons and control levers, thanks to torque converter and automatic transmission."

"As an example, our company will soon come out



A long stretch . . .

. . . to the bottom of this trench is no strain for the Gradall, made by Warner & Swasey Co. Completely hydraulically controlled, the long beam is easily rotated to any angle besides telescoping within itself. Quite versatile, the Gradall can be mounted on flat cars for railroad use, in mines, on barges for dredging, (it also was used as a paddle to move the dredge), open-hearth operations in steel mills, and others.

A Booming Market Gets More Equipment

Growth of Equipment in Use	Estimated Number 1955	Estimated Number 1957
Asphalt Plants	2,750	3,250
Batching Plants, concrete	11,500	13,000
Compressors, air, portable	42,500	46,000
Conveyors	20,000	20,000
Crushers, stone (stationary)	4,750	5,400
Crushers, stone (portable)	5,000	6,100
Dozers, bull and angle (not including tractor)	133,000	165,000
Finishing machines and spreaders, pavement	6,500	8,200
Graders, motor	68,000	81,000
Graders, pull	10,000	10,200
Hoists	15,000	17,500
Mixers, concrete and mortar, including pavers	100,000	120,000
Mixers, soil stabilization and bituminous	13,000	15,000
Pumps, portable (total)	135,000	153,000
Pumps, portable (with tires)	65,000	77,500
Rollers, pneumatic tired, pull type	16,000	20,500
Rollers, tamping, sheepsfoot, pneumatic	11,800	16,750
Rollers, road, self-propelled	23,500	29,000
Scrapers, carrying	36,000	43,500
Screens, rotary or shaker	8,000	8,700
Shovels, including cranes and draglines on truck chassis	11,000	16,250
Shovels, including cranes and draglines	56,000	63,000
Tractors, crawler	250,000	325,000
Tractors, wheel	18,000	25,000
Tractor loaders; shovels and cranes	65,000	94,000
Trench machines	6,500	7,600
Truck mixers and agitators	23,000	31,400
Trucks, off-the-highway	9,300	11,400
	1,166,100	1,413,250

Source: Construction Methods & Equipment Magazine

with a shovel loader controlled only by a front-back lever, foot throttle, brakes and two levers to control lifting and digging actions."

• Materials Not Used 5-10 Years Ago?

"Yes. High-strength, heat-treated alloys are used in certain fabricated frame members"—Fruehoff.

"We're using nodular iron castings to give more and lasting strength than gray iron castings."

"Using a high carbon alloy material instead of high manganese in our lip castings. Excavating contractors want buckets that will dig deeper without heeling. They are cost-conscious of replaceable parts such as teeth, and want parts that will wear longer"—Renner Mfg. Co.

"Aluminum weight alloy steels and plastics, the latter for panels and cabinetry"—Manning, Maxwell & Moore.

"We're using porous chrome to line cylinder walls. Also Teflon in lube and fuel lines on our diesels to decrease failure caused by vibrations"—McKiernan-Terry.

"Cast iron and ductile iron castings substituted for steel castings to reduce costs"—Tampo Mfg. Co.

"Primarily improvements of same basic materials used before"—M-R-S Mfg. Co.

"Molded nylon for cylinder packings and wear rings"—Clark Equipment Co.

"Too numerous to mention but changes involve using such newer materials as aluminum, nylon, plastic products, synthetic rubbers, and new steels and lubricants"—International Harvester.

"Using boron steel to increase the life of crawler tractor sprockets"—Caterpillar Tractor Co.

"Nylon bearings; polystyrene covers for packaging protected equipment"—Cleveland Formgrader Co.

"Lighter-manganese, lower-carbon steels to increase weldability strength and cold brittleness. Some alloy structural steel for extreme light weight. Silicone rubber for high-temperature application. Higher temperature insulation in electrical equipment to facilitate design of smaller components"—LeTourneau-Westinghouse.

More than 80% of the manufacturers queried foresee still further changes in choice of materials during next two years. More than 90% of the industry contacted said that their expenditures for R & D during recent years has increased—these figures ranged from 15% to 300%.

• Keeping Step With the Future?

On the subject of whether manufacturers of components used in the equipment were keeping up with needs and advancing technology, opinion was divided. Here's sampling of reactions:

"They are not keeping up in the areas of air-cooled and diesel engines"—Construction Machinery Co.

"Our needs are greater for improved hydraulic system components."

"In some instances perhaps not, but on the whole our component manufacturers keep abreast of technological developments. They have to, for competitive reasons"—Cleveland Formgrader Co.

"They're not keeping pace in power-transmission

components, engine components, and units of electrical systems, for example"—International Harvester.

"They haven't come up with a dependable 450-hp engine"—M-R-S Mfg. Co.

"Not keeping pace in transmissions and differentials, and inexpensive hydraulic parts. This is probably due to low volume in our particular needs"—Tampo Mfg. Co.

"Standard transmission design has not kept pace; so there is a greater need for hydraulic units. With an increase in equipment size, component suppliers are not keeping up in such items as: clutches; transmissions; and special type tires."

"We feel that iron foundries and steel forging suppliers are not giving us as good a product today as they provided 50, even 20, years ago"—McKiernan-Terry Corp.

"We have found no instances of these manufacturers failing to keep pace with us"—Caterpillar Tractor Corp.; Baldwin-Lima-Hamilton Corp.; Eagle Crusher Co.; Renner Mfg. Co.; Bay City Shovels, Inc.; Standard Steel Corp. Several companies said they felt the component-makers were not keeping abreast, but declined to elaborate.

• That Federal Program?

How much affect will the Federal Roadbuilding Project have on design of heavy construction equipment? Surprisingly, few companies expect any radical design departure.

"We have anticipated the program by design and engineering improvements which give customers the benefits that engineering research, new materials, and methods have made possible. While the program may give impetus to design, roads and streets are being built every day, and this is just another contract, albeit a large one."—spokesman for a major corporation.

Many companies replied with a definite "No, it won't affect design," while others qualified their answer with a "Not yet." Still others, but only relatively few, felt that the program would key dynamic new design:

"Existing R & D programs will be accelerated. Any program involving so much money and so many competing companies is bound to spark a design epidemic."

"With so much dirt yardage involved, we've had to step up our design plans for increasing capacity"—M-R-S Mfg. Co.

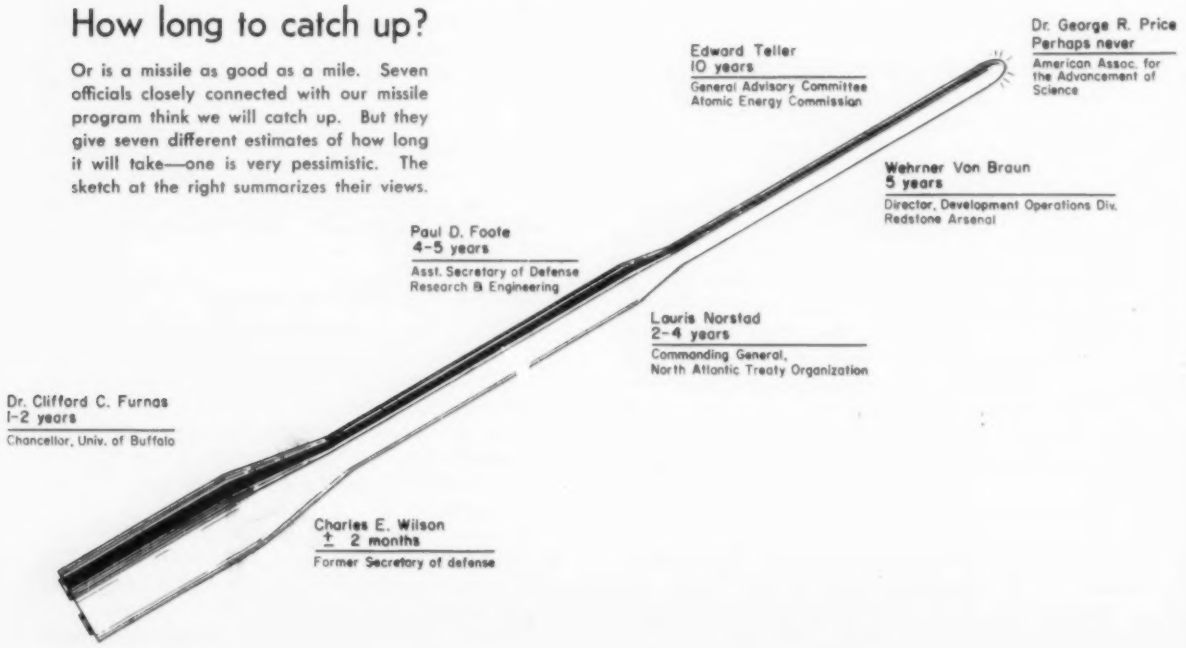
"Program will most decidedly spur design of more portable units"—McKiernan-Terry.

Summing up, our survey shows that industry leaders are advancing along six separate design fronts—improving rubber tires and expanding their use, improving metals, searching for more efficient lubricants, upgrading the horsepower of power plants while reducing their size and weight, simplifying work for the machine operator, and making servicing easier.

While there is a trend to designing larger equipment, to get more work accomplished with the fewest operational units, there is also considerable development of very small machines—most of them special-purpose. But large or small, the heavy-construction equipment manufacturer is requiring, more and more, something besides the advantages of size and power. He wants versatility. In demand is the tractor that can be a dozer, a prime mover, a crane, a backhoe, a front-end loader and a shovel. In demand is the mobile crane that can be a shovel, a crane, a materials-handling unit, a piledriver and a hoe. By drawing on advances in technology, the industry is driving ahead to meet such requirements and assure itself of continuing progress.

How long to catch up?

Or is a missile as good as a mile. Seven officials closely connected with our missile program think we will catch up. But they give seven different estimates of how long it will take—one is very pessimistic. The sketch at the right summarizes their views.



Can a Machine Translate Russian?

WASHINGTON—As the government's need for translation of foreign technical literature reached the alarm stage (see story opposite), a Russian-born librarian employed by Georgetown University's Institute of Languages and Linguistics reported development of a possible breakthrough in machine translations.

The librarian, Ariadne Lukjanow, working under the direction of Dr. Leon Dostert, institute director, proposes feeding numbers into the mechanical translator instead of words. The system calls for setting up a numerical code much like a telephone dialing code, creating an equal sign between the English and the foreign language being considered. The code contains both the English and the foreign meaning of words in grammatical categories applying to both languages.

Government agencies such as the National Science Foundation are reserving comment pending results of a test demonstration scheduled for early 1958. But Dr. Dostert has confirmed the development of PRODUCT ENGINEERING. He is the scientist who translated a number of Russian sentences four years ago, working with IBM's 701 computer.

Philogist Lukjanow worked with three other institute staff members to develop the system. According to Dr. Dostert, the system has been copyrighted following favorable reaction of IBM and government officials to preliminary demonstrations. However, he cautioned that volume translation via electronics is still in the remote future, although he believes his group will have established the first practical steps in digital and symbolic coding.

Specifically, the institute's new system, known as the matching technique, calls for reduction of ambiguity while syntax is accomplished by digital code appended to words in computer's stored memory.

In addition to the dictionary code are rules for syntax rearrangement, formulated in systematic digital code. For example, the machine may be faced with a word having several meanings. It arrives at the proper choice by matching the code of the "source item" (Russian word) with the "target" item—our word.

The group has now assembled a lexicon of 2100 Russian words and their English equivalents.

Though mechanical translation has been extensively researched for nearly 10 years now, this is only the second announcement of substantial progress since IBM's 701 translated some 60 Russian sentences using a 250-word vocabulary and five Russian syntax constructions.

Where Research Stands

The quest for mechanical translation started in 1946 when Warren Weaver of the Rockefeller Foundation first read a British physicist's report suggesting that computing machines might be adapted to translate languages. Today, studies are being made at Georgetown, M.I.T., Harvard, U.C.L.A., the University of Washington, and the Institute for Advanced Study at Princeton. IBM, Remington-Rand and Bell Telephone Labs are conducting applied research.

WASHINGTON—The U. S. can't hope to have electronic translators perfected before 1959, and perhaps not before 1962.

This pessimistic view holds even if Miss Lukjanow's system proves successful in the test to be held early in 1958. The test: translation from Russian to English of a 2000-word 30-page technical paper on organic chemistry. The IBM 705 will be used.

Government officials are awaiting the outcome with interest. They've heard Russia is already using machine translation.

Any solution to the problem, including Miss Lukjanow's, must involve five basic steps: (1) feeding the original text-written or spoken- into the machine; (2) transforming this text into symbols the machine can handle; (3) translating the meaning from one language to another; (4) turning the translation back into conventional words or other units in the new language, and (5) presenting the translated text.

Here's a rundown on developments in these five areas:

Steps 1 and 2. Text must be reduced to digestible form before it can be fed into a machine, but because there is no universal syntax, direct recognition of written or spoken words must be made possible. Automatic checkreading machines being developed for banks may be the first devices to use such a recognition system.

Other problems here relate to recognition of different fonts, sizes of type. Translating spoken language into machine code is being studied by Bell Labs which hopes that analyses of meaningful speech elements will lead to equations for programming machine translation of speech into written or speech form.

Step 3. There is very little difficulty in the computer-translation step. IBM's 705 general-purpose machine, updated version of the 704, will accomplish this. However, word inflection poses a problem.

To solve this, Harvard's Anthony Oettinger has suggested that a machine be equipped with built-in circuits for identifying inflectional endings immediately, and, if necessary, stripping the ending off. Then the machine would lock up the stem in its memory. Meanwhile, to complete the meaning of the word, the machine would also hunt up in a separate memory the sense of the stripped-off inflectional end. Irregular words, a big problem for human translators, would simply be translated directly.

Concern over computer storage capacity for mammoth vocabularies has been relieved by development of extremely compact magnetic devices, created out of basic research in magnetism and crystal structure.

The ideal machine will have to process entire sentences. An approach to this problem developed by Victor H. Yngve of MIT is considered the most promising: separating into distinct vocabulary categories the high frequency words of little meaning (of, the, by, etc.) from the low frequency words that provide the structural framework. Yngve and his colleagues are writing rules to make Syntax information completely explicit.

Steps 4 and 5. No great difficulties have appeared and time will provide the practical refinements.

But the scientists who develop such computers must wait for linguists like Dostert who are trying to reduce vocabularies to common denominator.

SOURCE SENTENCE: vyelyichyina ugla opryedyelyayetsya otnoshyenyiyem dlyini dugi k radyiusu.

ANALYSIS:

RUSSIAN WORD	ENGLISH EQUIVALENTS I	ENGLISH EQUIVALENTS II	1st CODE	2nd CODE	3rd CODE	RULE NO.
vyelyichyina	magnitude	- - -	***	***	**	6
ugl-	coal	angle	121	***	25	2
-a	of	- - -	131	222	25	3
opryedyelyayetsya	is determined	- - -	***	***	**	6
otnoshyenyi-	relation	the relation	151	***	**	5
-yem	by	- - -	131	***	**	3
dlyin-	length	- - -	***	***	**	6
-i	of	- - -	131	***	25	3
dug-	arc	- - -	***	***	**	6
-i	of	- - -	131	***	25	3
k	to	for	121	***	23	2
radyius-	radius	- - -	***	221	**	6
-u	to	- - -	131	***	**	3

TARGET SENTENCE: magnitude of angle is determined by the relation of length of arc to radius.

IBM RULES FOR SYNTAX . . .

Rule 1: rearrangement. If first code is '110,' is third code associated with preceding complete word equal to '21?' If so, reverse order of appearance of words in output; i.e. word carrying '21' should follow that carrying '110'—otherwise, retain order. In both cases English equivalent I associated with '110' is adopted.

Rule 2: choice—following text. If first code is '121,' is second code of the following complete, subdivided or partial (root or ending) word equal to '221' or '222?' If it is '221,' adopt English equivalent I of word carrying '121;' if it is '222,' adopt English equivalent II. In both cases, retain order of appearance of output words.

Rule 3: Choice-rearrangement. If first code is '131,' is third code of preceding complete word or either portion of preceding subdivided word equal to '23?' If so, adopt English equivalent II word equal to '131,' and retain order of appearance of words in output—if not, adopt English equivalent I and reverse order of appearance of words in output.

Rule 4: choice—previous text. If first code is '141' is second code of preceding complete word or either portion (root or ending) of preceding subdivided word equal to '241' or '242?' If it is '241,' adopt English equivalent I of word carrying '141'—if it is '242' adopt English equivalent II. In both cases retain order of appearance of words in output.

Rule 5: choice—omission. If first code is '151,' is third code of following complete word, or either portion of following subdivided word equal to '25?' If so, adopt English equivalent II of word carrying '151'—if not adopt English equivalent I. In both cases, retain order of appearance of words in output.

Rule 6: subdivision. If first code associated with a Russian dictionary word is '***', then adopt English equivalent I of alternative English language equivalents, retaining order of appearance of output with respect to previous word.

US Translation Program Bogging

WASHINGTON–Very little of the valuable information in Russian scientific journals is reaching US scientists. Only 40 or so Russian technical publications are being translated here.

Top US officials say they'd like to see at least 200 scientific journals translated on a regular basis. They rate these of prime importance among the 1000 the Russians publish. By contrast, the Russians regularly translate each issue of about 1400 of the estimated 1800 US journals.

The US program is not only small but uncoordinated as well. On an informal basis the government's Interdepartmental Committee on Scientific Research and Development attempts to keep member agencies informed of translation activities. But it has no authority to say what an agency should translate or who gets the translation. There is no central library of translated documents or a catalog listing sources of translated material.

Within the government, translation of Russian documents is sharply divided between military and non-military agencies. Non-military groups spend less than $1 million a year on translations. The military, including intelligence services, spend a far greater amount, which they cannot reveal. Commercial translating firms produce for non-government clients about as many translations as non-military government agencies.

Business firms and research organizations have no difficulty subscribing

to translations available from nonmilitary sources. But military agencies still classify theirs. The theory is that it will help the Russians to know which areas of science interest us most.

The US translation program is headed for major changes. Security wraps on military translations will probably go within a few months. Revision of military policy is on the agenda of Dr. James Killian, the President's new advisor on science and technology.

Early next year the House Government Information Subcommittee, headed by Rep. John E. Moss (D-Calif.) plans to start a round of hearings on the issue. Initially legislators will call in some of the nation's top scientists to get their views. They want to find out what importance scientists give to translations. Then attention will focus on how best to set up a program.

The National Science Foundation is plugging to have its annual budget for translations increased from around $300,000 to $500,000. And it wants to set up a central clearing house for all scientific information.

The Commerce Department also has a plan to establish a clearing house for translated technical information of industrial or engineering information. Estimated cost for getting the program under way is $1 million.

And machine translation, (see opposite), which may eventually be helpful, strongly interests the military.

Many problems confront the architects of a stepped-up translation program. For one thing, scientists in different fields work with information in different ways. Some use abstracts, others prefer to work with source material.

Some scientists feel documents must be translated by specialists in the field, not professional translators. But scientists capable of good translations don't want to give up the time.

Current US Translation Effort

National Science Foundation supports translations through grants to scientific institutions in physical and natural science. The bulk of its effort goes into complete translation of 15 technical journals considered the best in a nationwide survey. They are available about six months after publication.

The Special Libraries Association Translation Center (John Crerar Library, 86 Randolph St., Chicago.) is a depository for translated documents contributed by government agencies, industry and universities. SLA has about 17,000 documents now and is adding 400 a month. Its "Translation Monthly" lists all foreign-language documents on deposit as well as those available from some domestic and overseas depositories.

The Library of Congress publishes a "Monthly List of Russian Accessions" that gives English titles, authors and tables of contents of all periodicals received by it or any of its 200 cooperating libraries. Microfilm or photostat copies in Russian are available.

The AEC spends around $100,000 a year on its own or sponsored translations. Abstracts of unclassified translations are published in its bi-weekly "Nuclear Science Abstracts." The AEC maintains a file of all translation cited. These are available on micro-cards or photocopies.

The Armed Services Technical Information Agency acts as a clearing house for the services translations. About every 10 days it publishes three bulletins listing documents received —one for unclassified material, one for limited circulation, and one for classified material.

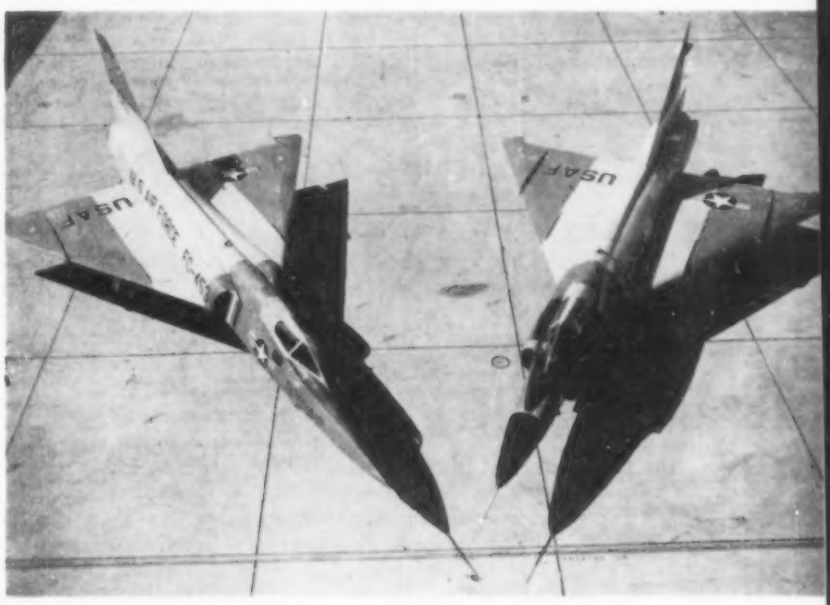
Unclassified material is channeled to Commerce Department's OTS for distribution to industry. The volume of material that gets to OTS, critics say, is small and late. The OTS lists its acquisitions in the monthly US Government Research Report.

Russian Efforts

The Russians have a fairly elaborate translation program. They keep a permanent staff of over 2000 full-time translators and 20,000 part-time.

The service is fast. Translation of an entire journal takes six months. They also issue a series of 13 "Express Information" documents, which get abstracted information into the hands of key scientists before the journals are completed.

The "Express Information," May 19, 1956, contains abstracts from a February issue of PRODUCT ENGINEERING. In some cases abstracts come even faster—or as some US scientists believe, about as fast as anybody here gets them.



Spot the differences . . .

between F-106 Delta Dart, left, and F-102 Delta Dagger, right. Vertical stabilizer, engine air-inlet ducts, and wasp-waisting are chief external changes. The F-102's Pratt & Whitney J-57 engine has been replaced by a P&W J-75 in the Dart, and an advanced automatic armament system added. Both carry Falcon guided missiles.

Up Design Patent Protection; "Still Not Enough!" Say Designers

CHICAGO–Legislation has been introduced in Congress aimed at providing patent-copyright protection for the nation's industrial designers but the majority of the latter feel adequate protection is still a long way off.

This attitude was offered by George E. Frost, patent attorney, who, addressing a meeting of the Chicago chapter of the Industrial Designers' Institute, decried the fact that industrial designers have too long been helpless to prevent copying of original designs.

The legislation that will afford at least some surcease is contained in the Willlis bill, H.R. 8873, and provides:

- That the "author" of an ornamental design for a useful article can obtain protection for a renewable 5-year term by either making the design known to the public with the appropriate notice or by filing an application for design registration.
- That in the event the design is made known to the public, an application for design registration must follow within six months.
- The design notice should include the year from which protection is measured and the name of the proprietor. Special provisions are made for notice where normal application would mar the work and in cases of material having repetitive designs.
- Before an application can be made, a prototype, appearance model, or mockup in full size and in full execution of the design must be provided.
- Protection under the act extends only to copying of the registered design; injunctive relief and award of damages can be had against infringers.

This bill represents the efforts of leading men in the legal, industrial and designing fields, serving under the chairmanship of Giles S. Rich, judge of the US Court of Customs and Patent Appeals, a far cry from the first protection given industrial designers.

It was in 1842 that a Design Patent Act was approved by Congress. This legislation distinguished between "invention" and "skill of the art" making it encumbent on the designer to prove to the court that his work was not merely a refinement of established principle.

By 1870 a copyright law was enacted to cover "pure art" forms but industrial designers were at least getting a foot in the door. By 1909 the law was broadened to allow for "works of art, models and designs for works of art."

Shortly before 1950 the Supreme Court ruling in a case between Mazer and Stein decreed that art can be contained in work applied to established pieces of manufacture–in this case, lamps with sculptured figurines.

The justices stated, "The economic philosophy behind the clause empowering Congress to grant patents and copyrights is the conviction that encouragement of individual effort by personal gain is the best way to advance public welfare through the talents of authors and inventors in science and other useful arts. Sacrificial days devoted to such creative activities deserve rewards commensurate with services rendered."

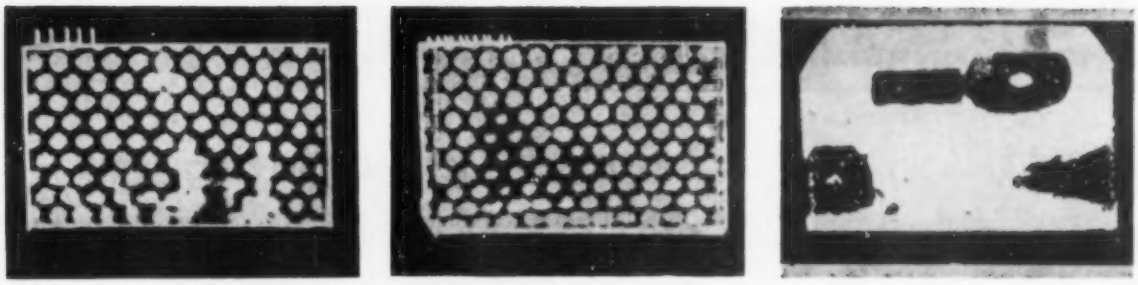
Expand Tests to Pick Machine Designers

NEW YORK–A program of tests aimed at picking out students with special capacity for creative machine design has been devised at Iowa State College with the assistance of the Office of Naval Research. A description of this program was offered by J. F. Downie Smith, dean of engineering at Iowa State.

The testing program takes note of the two main divisions of machine designers–creative and non-creative. At the outset, tests were keyed to discovering students at the junior year level who demonstrated abilities to comprehend nature of a design problem, and could produce an original solution to a problem involving a functional and practical mechanism. Noncreative designers would have to show aptitude in working out routine problems, and smoothing out design according to established principles.

In order to overstep the restrictive nature of a 2-dimensional categorization, Iowa State devised an additional 9-step test approach:

(1) power-source apparatus–given a power source and a motion source, student should sketch as many intervening mechanisms as possible; (2) design a machine–given a particular purpose to be served, student to sketch as many appropriate mechanisms as possible; (3) applications of mechanisms–given a particular mechanism, student enumerates as many types of machines as possible in which it might function; (4) 3-dimensional space relations–student to fold a flat pattern to form a cube, then indicate the position of three faces following various patterns of rotation; (5) figure matrixes –student to derive the rules by which a figure evolves in two dimensions and apply these in order to supply a missing figure at any given point; (6) number series–student to derive the rule or principle by which a series of numbers is generated and apply it to supply certain missing numbers in each series; (7) unstructured test–student is given a series of meaningless, mechanical drawings which he must point out and envision as to potential application; (8) personnel inventory–a paired statement inventory of 197 items dealing with interests, opinions, attitudes, personal characteristics and experience; and (9) personal history.



View on the display tube . . .
(Left) Stainless-steel honeycomb, with a 0.020-in. thick skin, showing an excess of bonding agent. (Center) Stainless-steel honeycomb (0.020) in. thick) showing a lack of bond. (Right) A 5-layered sandwich material showing intentionally placed voids at different levels. Equipment also can be used to detect flaws in castings.

Ultrasonics Test Honeycomb Bond

PASADENA, CAL.–One of the major problems connected with the use of metal honeycomb structure is that of inspecting the completed part to determine the soundness of the honeycomb and the strength of the bond to the panel skin. Using ultrasonics, Automation Instruments, Inc., Pasadena, Cal., has developed equipment for the non-destructive inspection of both brazed and bonded honeycomb sandwich panels.

Large panels are completely tested with a new ultrasonic transducer coupled to an Immerscope to "map" the sub-surface area. The exact pattern of the bonded area (see photos above) is reproduced on a Hughes Memetron tube, giving a record of up to 900 sq. inches. Spot checking is of little value, as just a few undetected "weak links" can cause the failure of an entire structure. Excess bonding can cause trouble too–uneven strength, uneven heat dissipation and excess weight.

The function of the transducer and Immerscope is to generate and transmit the ultrasonic impulses, to pick up the "echo", and provide an "A" trace on the Immerscope tube whose vertical displacement represents the intensity of the return signal. This "A" trace then becomes the "C" trace of the Memetron so that the X and Y axes of the resultant image represent the length and breadth of the area inspected. Intensity of trace is a direct representation of the mass of material at depth of inspection.

The ultrasonic signal is transmitted to the inspected part through a conducting fluid, usually water. If possible, this is done by complete immersion in an inspection tank. If immersion is not possible, the same results can be obtained by directing a stream of water at the test specimen.

Safety First—in Space Travel Too

NEW YORK–Rocket flight to a satellite orbit will probably be about as safe as a trip on today's conventional aircraft.

This high degree of reliability was predicated for a METEOR type vehicle by three Goodyear Aircraft Corp. engineers–Darrell C. Romick, W. M. Chappell, and Samuel Black–at the annual meeting of the American Rocket Society here.

The METEOR (Manned Earth-satellite Terminal evolving from Earth-to-Orbit ferry Rocket) is conceived as a vehicle to ferry men and materials to an orbit which will serve as a jumping off point to outer space. It is a three stage vehicle with all stages manned.

Use of crews on booster stages is proposed to cut the cost of establishing and supplying a manned satellite by salvaging and reusing the first two rocket stages. Crews of the booster rockets will fly their ships back to earth in a ballistic-hypersonic glide path similar to that used by the X-1 and X-2 research rockets. Booster stages would be of delta design as in the Hustler B-58 bomber.

In considering probability of failure, the authors have analyzed three critical functions–powerplant, guidance and control, and auxiliary power. Failure of any of these systems would have a more severe effect on a rocket than on conventional aircraft. Failure from other causes–structure, fire, etc. –has an effect more nearly parallel to conventional craft.

Improper operation of a critical system does not necessarily mean the mission will fail. Small difficulties can be expected to occur oftener than once in every 1000 trips. But the rocket would be designed with more power than necessary to get to orbit, with parallel guidance systems and other protections against minor failure.

In case of more serious failure, the crew would have to sever the three rocket sections and fly back independently. In even more severe breakdown the crew, particularly those in the first stage, might have to abandon the vehicle. Cases in which the ship fails to attain its orbit or the first stage of equipment is lost through crew abandonment could be expected to occur once in every 2000 flights.

Failure fatal to crew in the third stage–first and third stages are the most hazardous–would occur about as often as fatalities in today's aircraft.

The authors have forecast that reliability development will be rapid.

Bits and Pieces

"When a country as widely respected for its individualism as ours produces mass man, I get horribly scared," said Dr. Bernard I. Spinrad, director of Argonne National Lab's Reactor Engineering Div., in decrying the status of our engineering education program. He added that society loses a very decided fraction of the brilliance available to it by the delay in the education of people who can do brilliant things. "This delay," he said, "can be traced in large part to the premium being placed on social adjustment in schools, rather than intellectual achievement." . . . .

TITANIUM PRICE DROP

Increased use of titanium has dropped its price to $10.60 ; in 1950 the price was $25.00 a pound. . . . Using 90% hydrogen peroxide as the test medium, a new flow test system for airborne and ground missile equipment has been developed by Aerotest Labs, College Point, N. Y.; good for components such as valves, pumps, hose lines, couplings, disconnects, for static pressures up to 3000 psi and a wide temperature range. . . . Harvey Aluminum Co. is calling its missile body section the largest impact extrusion in the world. Its measurements: 32 in. long, 14 in. in dia., a wall thickness of 0.875 in., weight of 112 lb., and is stepped at one end. Produced on a production basis, the alloy is 2014-T6 with a finish of RMS 125 or better. . . .

THE FEMALE TOUCH

In an increasing effort to appeal to the female buyer, the automotive manufacturers are looking to some of the country's top custom upholsterers and fashion experts for inspiration. Chrysler is making available 2000 different color combinations for its fabrics in the 1958 model line. Vinyl plastics and irridescent fabrics are being used extensively. . . . Chrysler Corp's Engineering Div. has opened a new laboratory devoted to the study of sounds and vibrations of cars and trucks.

Tax Refund for Moving Isn't

WASHINGTON–Refunds to individuals who paid tax on moving expenses received from hiring firms are a long way off–at best.

The government is contesting two decisions reached by the US district court of New Mexico, which instructed the Internal Revenue Service to refund taxes collected from plaintiffs in Albuquerque (Nov. 4, '57, p. 26).

IRS has appealed the case to the Circuit Court of Appeals. Circuit courts take roughly six months to reach a decision–though this varies with the court calendar. If the circuit court rules in favor of the plaintiffs, IRS must refund the money, but need not alter its tax policy. Only a Supreme Court decision can force a policy change.

A rash of district court decisions against IRS would probably induce a revised policy. Individuals who paid tax on moving expenses would do well to file a claim, the bureau says. A change in policy is retroactive for three years. And the Service will honor claims filed with it for open tax years.

Aluminum Eyes Auto Market

DETROIT–Transportation will be the largest single market for aluminum, says Richard S. Reynolds, Jr., president, Reynolds Metals. He predicts consumption will top 10 million by 1975–five times present use. The big market will be split this way:

- Transportation: 3 million tons, primarily automobiles, a seven-fold increase over current consumption.
- Construction: 2 million tons, a four-fold gain over the present 500,000 tons.
- Electrical industry: 1 million tons. Present use, 250,000 tons.
- Military applications: a big gain, in armament for airborne troops.

* * *

Add one new entry to the research-lab roster. Detroit Harvester has announced plans for a $500,000 research center and headquarters to be completed in early spring. The center will be used for testing and experimentation as well as central headquarters for the company's eight plants.

The firm now manufactures top frame assemblies for automobiles, components for appliances, power mowers, spray booths, agricultural equipment, posthole diggers.

* * *

Training in new scientific techniques is scheduled for high school and college teachers at Wayne State Univ., Michigan State College, Northern Michigan College and Western Michigan College. They will split a $5 million appropriation from Congress for summer refresher courses. One program at Wayne will train 20 teachers in radiation biology.

* * *

The windows on your car may be power operated in most 1961 automobiles. For a switch, you may get hand operation as an option at extra cost. Reason: a leading Detroit company has developed a simple, almost foolproof, and cheap method of getting those panes up and down.

COMING EVENTS

JANUARY

6-8 . . . Symposium on Reliability and Quality Control sponsored jointly by AIEE, RETMA, IRE and American Society for Quality Control. Hotel Statler, Washington.

27-29 . . . American Society of Heating and Air-Conditioning Engineers 64th annual meeting, Penn-Sheraton Hotel, Pittsburgh, Penna.

28-31 . . . Society of Plastics Engineers, 14th Annual National Technical Conference, Hotel Sheraton-Cadillac, Detroit, Mich.

29-30 . . . Midwest Welding Conference sponsored by Armour Research, Illinois Institute of Technology, and Chicago Section American Welding Society at Illinois Tech Chemical Building, 3255 Dearborn St., Chicago.

OVER-DESIGNING?

If you are designing bronze parts for mass production, there is a good chance that you are specifying a more costly alloy than you need.

ASARCO's patented continuous-casting process produces alloys according to SAE, ASTM and Government specifications. But their performance is entirely unlike that of similar alloys cast in sand or permanent molds. Relatively low-cost alloys cast by the ASARCO process perform like more expensive alloys cast by other methods.

For example, compare Continuous-Cast SAE 660 (ASARCON 773) with more expensive sand-cast alloys:

	Typical Yield Strength	Typical Impact Strength	Brinell Hardness
ASARCON 773	27,000 psi	12.5 ft.-lbs.	72
Sand-Cast SAE 62	20,000 psi	8.7 ft.-lbs.	65
Sand-Cast SAE 64	17,000 psi	8.2 ft.-lbs.	62

Unless you've checked to see whether the unique ASARCO bronzes can give you what you need, there's a possibility that you're over-designing. You may even be able to replace aluminum and manganese bronzes with low-cost ASARCON Continuous-Cast bronzes under certain conditions. Over-designing can be expensive in mass production, even if you are spending only a penny or two extra per pound of bronze.

ASARCON 773 (SAE 660) is readily available from stock in a wide range of sizes. An added bonus is the fact that ASARCON 773 is exceptionally free-machining. Rods, tubes, and numerous "extruded" shapes up to 9 inches in diameter are cast to order by ASARCO in more than 20 alloys.

We'll be happy to send you a free booklet describing the process and the product.

Continuous-Cast Products Department

AMERICAN SMELTING AND REFINING COMPANY

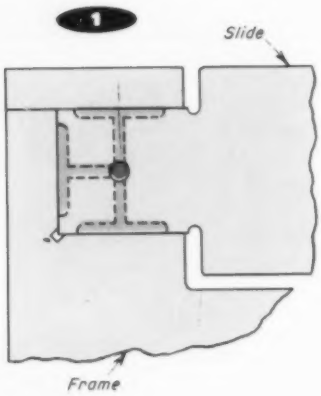
Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

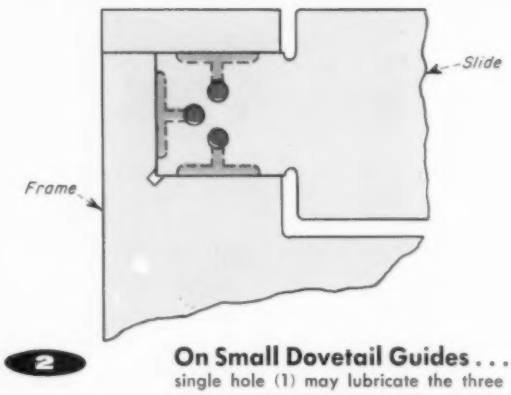
WEST COAST SALES AGENT: Kingwell Bros. Ltd., 457 Minna Street, San Francisco IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal

How to Lubricate Ways

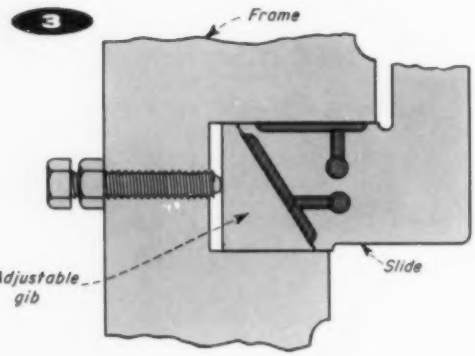
. . . small dovetail guides, angled and circular ways

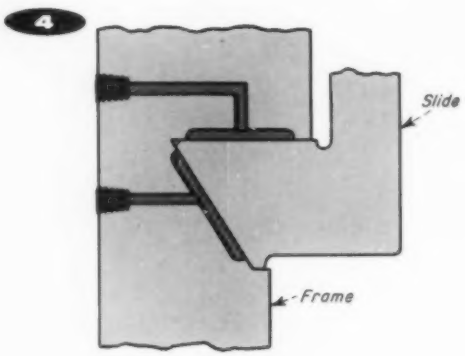
Nine more examples. For nine horizontal, vertical and cross-slide ways see December 9, 1957, page 114.



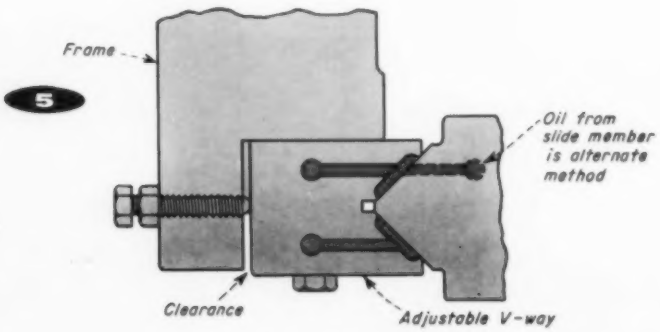


On Small Dovetail Guides . . . single hole (1) may lubricate the three surfaces. On larger machines it is better to oil each surface individually (2) to prevent oil drainage through corner clearances.

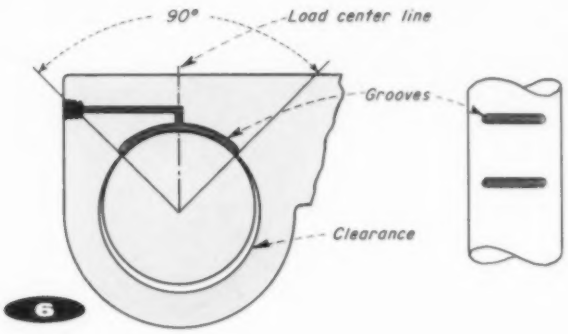




Three Forms of Angled Ways . . . Method at (3) requires introduction of oil through slide to prevent leakage through clearance at back of gib. When no gibs are used (4) oil may be fed from frame. In some construction (5) oil must be carried through adjustable V-way member from the V-end-face to eliminate leakage through gib clearance.

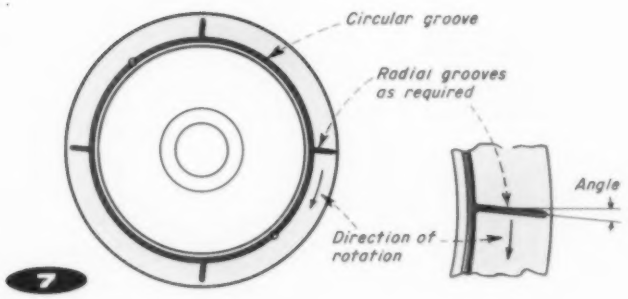


W. O. WRIGHT
Bijur Lubricating Corp.



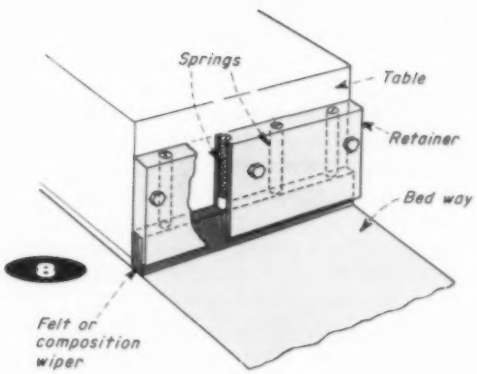
Cylindrical Ways . . .

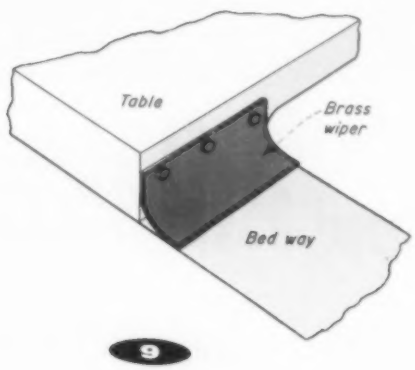
should be provided with one or more cross grooves extending about 45° on each side of the bearing load-center. Spiral or "figure-eight" grooves are not recommended; this type allows oil to flow to bearing clearance, leaving load area unlubricated.



Circular Ways . . .

are improved by angling the radial grooves leading from circular groove. Angle should be such that table movement traps oil in groove. This allows oil to be wiped onto bearing area rather than merely carried around circular groove.





Way Wipers . . .

can become poorly adjusted and should be inspected periodically. Bad contact with the bed ways can result from clogged or hardened felts (8). These must be replaced if not in good condition. Effectiveness of metal wipers (9) also depends on regular inspection and adjustment to insure light contact between wiper and way surface, and replacement of badly worn wipers.

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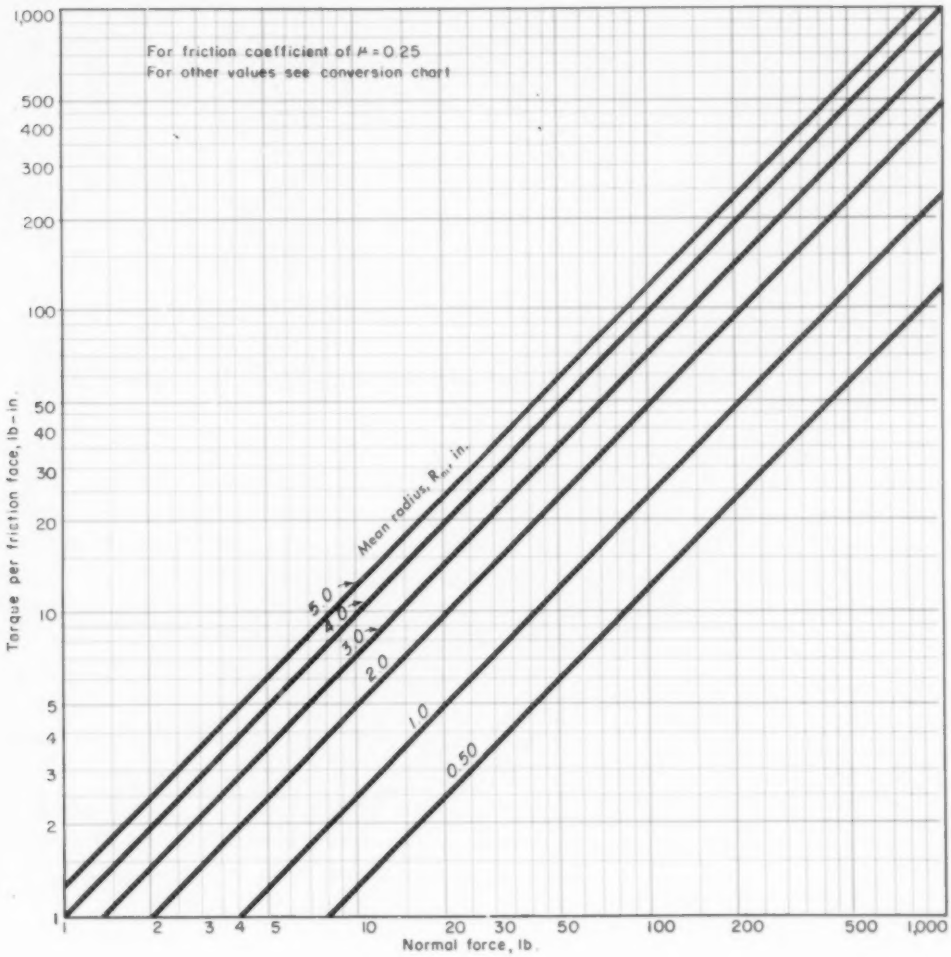
Torque of Slip Couplings

Here are formulas and charts of force, torque and friction conversion-factors for slip couplings from 0.50- to 5.0-in. mean radius.



All slip-coupling designs consist, basically, of one member pressing against another. Friction face can be metal or some other material. When torque force exceeds the friction force between pressed-together faces, they slip relative to one another. Usually, pressure is adjustable so driving torque can be varied. Some form of flexible coupling should be mounted on one of the shafts close to the slip coupling.

For each friction face of a flat-disk coupling, torque, force and friction are related in

$$T = \mu F R_m$$

This formula is also true for cone couplings. If pressure is uniform throughout the friction face area the effective mean radius is

$$R_m = 2/3\left(\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right)$$

When the friction face is between mating cones

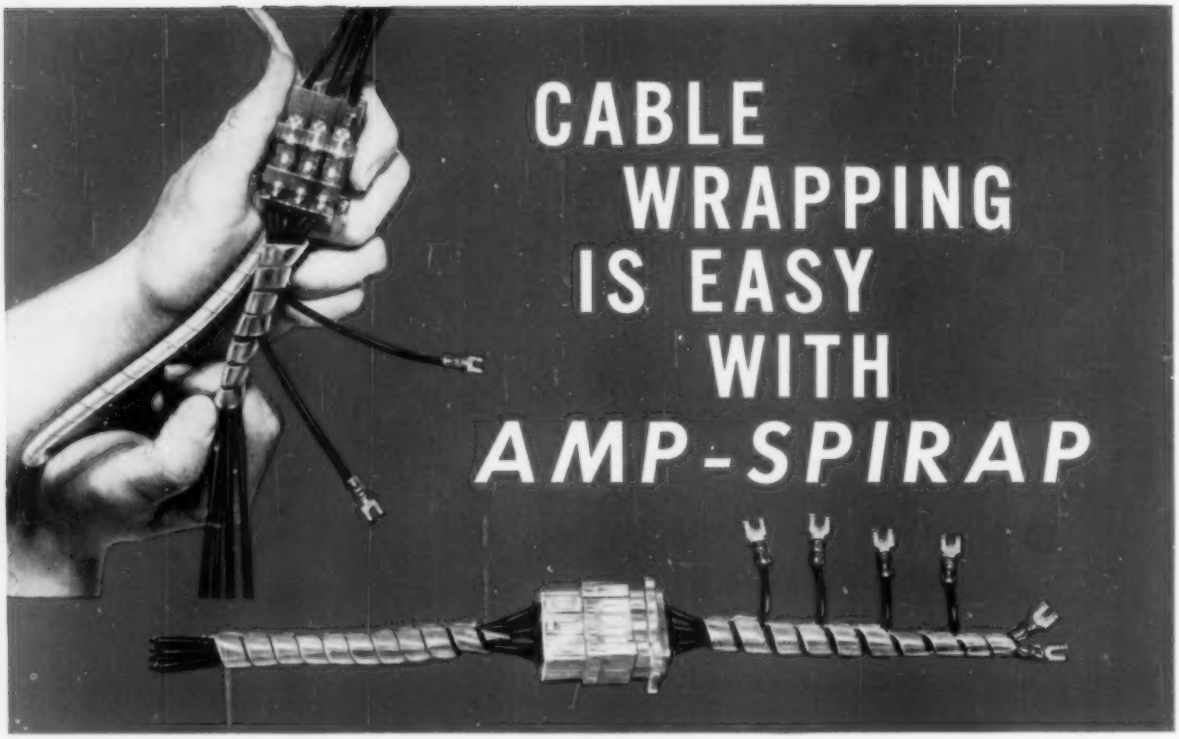
$$F = \frac{F_a}{\text{Sin } \alpha}$$

If the cones are slipping, this becomes

$$F = \frac{F_a}{\text{Sin } \alpha + \mu \cos \alpha}$$

The face angle for cone couplings can range from about 7 to 30°. Usually it is about 12½°.

(continued on page 97)



The development and production of the finest quality solderless terminals for your electrical circuitry requirements is AMP's primary objective. We also constantly search for allied products and application techniques that will speed, simplify, and obsolete present time-consuming sub-assembly operations. *AMP-SPIRAP* and its application technique stems from such constant searching activity.

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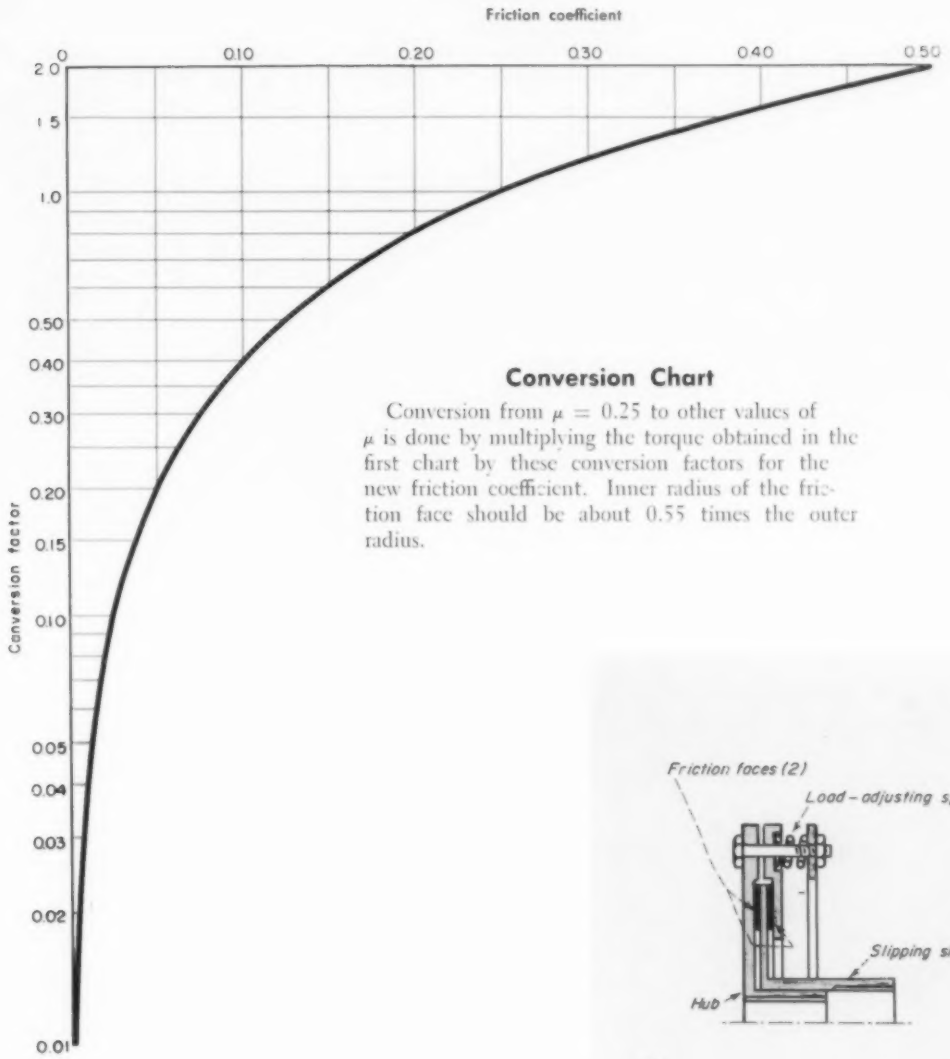
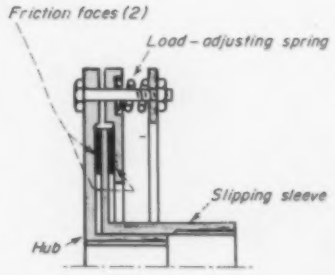
Torque of Slip Couplings *(continued)*



Conversion Chart

Conversion from $\mu = 0.25$ to other values of μ is done by multiplying the torque obtained in the first chart by these conversion factors for the new friction coefficient. Inner radius of the friction face should be about 0.55 times the outer radius.

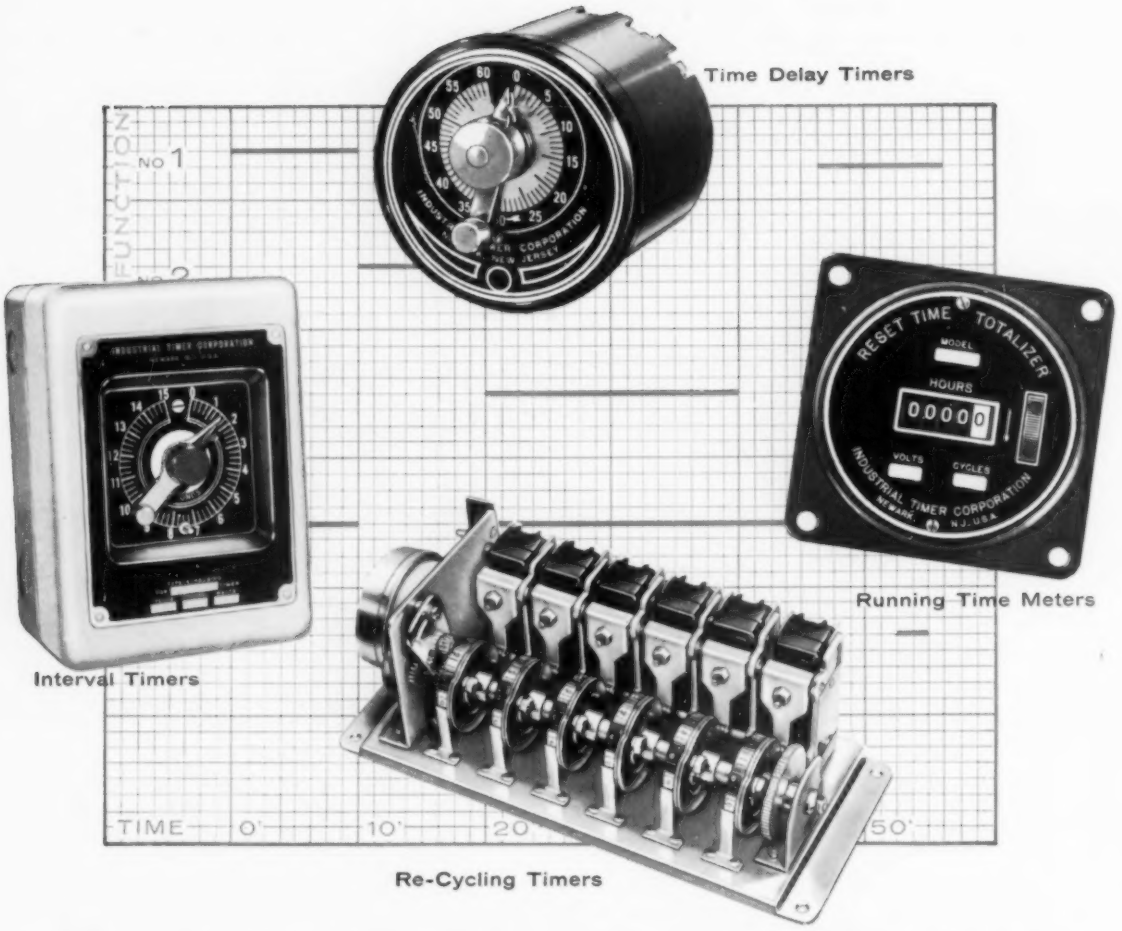


Maximum unit pressure for various friction materials should not be exceeded. While this is not so likely to occur in slip couplings as in clutches, it should nevertheless be checked. Maximum pressures for friction faces are available in most engineering handbooks.

If desirable to stop the drive when slipping occurs, a warning device such as a clacker can be mounted between the two members of the drive—movement of one relative to the other will be audible. An electrical contact similarly mounted can be connected through a slip ring to stop the drive automatically.

Symbols

F = force normal to friction face, lb
F_a = axial force, lb
R_m = mean radius of friction faces, in.
R_o = outer radius of friction faces, in.
R_i = inner radius of friction faces, in.
T = torque, lb-in.
n = number of friction faces
α = cone angle relative to shaft axis
μ = friction coefficient



Timers for Automatic Control ...Standard or Special?

You'll get quick deliveries from Industrial Timer

If slow deliveries of timers have been delaying you in your automatic control projects, try us! True, your problem may be different and difficult indeed, for no two automatic control jobs are exactly alike. But our record in helping out in situations like these is excellent. For in this field we have a valuable background, twenty years of timer experience to be exact, that has provided us with the special knowledge required to supply our customers with the right answers.

How do we do it? The answer is in what we believe to be the largest variety of standard and combination timer units anywhere in the industry. To fill the widely varying needs of our customers, we manufacture a complete line of timers in the four broad classifications illustrated above: Time Delay Timers, Re-Cycling Timers, Interval Timers, and Running Time Meters. From these our timer engineers have developed 20 basic types which they have so far combined in over 1000 different ways. Therefore—many jobs that would seem to require a special timer, are in fact, a standard timer with us.

And our large stock assures you of rapid deliveries—even when we have to create a brand new timer for your special needs. So why not send us your specifications. You'll get a prompt reply and you may save yourself much lost motion.

Timers that Control the Pulse Beat of Industry

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Pay Of College Teachers... Where The Russians Are The Capitalists

This editorial deals with a simple question about college faculty salaries: Which country pays its teachers better, Russia or the United States? It's a good question, with a sadly embarrassing answer.

That American college and university teachers are underpaid is not a novel observation. But what has happened to the economic status of their profession can be put in more candid terms. **As far as financial incentives are concerned, we have virtually socialized the academic profession.** Teaching has become such a poorly paid career, with so little prospect of material reward for outstanding performance, that it simply does not attract enough highly qualified young men and women.

Ironically, the Soviet Union has deliberately and successfully used capitalist incentives to improve its educational system. Although the Russians show an utter disregard of civil liberties, they pay their teachers well and confer on them all the prestige and privileges the Soviet society can offer. Russian professors, together with party officials and scientists, have become the privileged upper class of a supposedly classless society.

Incentives To Be A Teacher

To be a college teacher requires high intellectual competence and long, sometimes costly, formal training. Aside from the appeal of academic life, what incentive does college teaching offer bright young men and women?

In the U. S., the average faculty salary is little more than the average income of industrial workers. According to the National Education Association, the average faculty salary is about $5,240. College instructors receive $4,100, associate professors $5,730 and full professors $7,100. The average income of U. S. factory workers in 1956 was $4,580.

Actually, workers in many industries — steel, automobile and petroleum, for example—earn more on the average than college teachers. And skilled workers often earn more than full professors at some of our colleges and universities.

In Russia, on the other hand, the young Soviet graduate can see that it pays — and pays very well — to choose teaching as a career. The head of a department in a Russian university can command a salary of about 6,000 rubles a month.* This is about eight times the income of the average Russian worker, who earns 750 rubles a month.

The Russian professor comes off very well in terms of what his income will buy. It has been estimated that, based on Soviet consumption patterns, 6,000 rubles a month is worth about $7,200 a year — or higher than the average professor's salary in the U. S. Of course, it is difficult to compare living standards in two countries as different as the U. S. and Russia. But particularly in the field of science — where the salaries can run to 15,000 or more rubles a month — it is clear that the Soviet professor enjoys a higher real income than that offered his American counterpart by a much more prosperous economy.

Incentives To Be A GOOD Teacher

Russia also offers much higher premiums than the U. S. to those who attain distinction in teaching. Teachers at the university level earn significantly more than teachers in high schools, and university instructors can look forward to a sharply progressive rise in earning power as they

* *Soviet Education for Science and Technology* by Alexander Korol of the M.I.T. Center for International Studies.

How Faculty Salaries Compare With Industrial Wages

(Worker's Wage In Each Country = 100)

*Sources: Center for International Studies, M.I.T.; National Education Association; McGraw-Hill Department of Economics

advance to higher positions. The spread between the income of a full professor and the lowest academic position is greater than fifteen to one. In addition, full professors can earn a healthy bonus if they are elected to membership in the Russian Academy of Sciences.

In the U. S., by contrast, full professors on the average earn less than twice as much as beginning instructors. And many college professors earn less than public school teachers in large cities. Even a full professor's pay does not compare with earnings in other professions or in positions in industry requiring similar training. The point was well summarized in a recent speech by Marion B. Folsom, Secretary of Health, Education and Welfare: "It is nothing short of a national disgrace that we are discouraging people who want to teach by offering salaries that are far below the levels justified by their training and far below the levels which others are willing to pay."

Our colleges and universities, as well as our teachers, find themselves in a serious predicament. Faced with a shortage of both funds and teachers, they cannot reward distinguished performances. Limited resources for salary increases have gone predominantly to the lower ranks, so that an adequate number of teachers could be retained. Meanwhile, potentially fine teachers are being siphoned off into better paid occupations.

The shabby treatment of our teachers threatens to undermine, not only our educational standards, but our free enterprise system itself. There is the recent example of a liberal arts college which discovered that five of its graduating seniors were being offered starting salaries higher than those paid any of their professors. It would be surprising if experiences like this did not place a strain on the enthusiasm with which these professors deal with some key aspects of American capitalism.

Also important is the role education is playing in the cold war with the Soviet Union. The Russians have made great strides in raising the quality of their education — particularly in science and engineering. Both the number and the technical calibre of their graduates are impressive, as recent Soviet achievements testify. These successes owe much to the generous economic treatment the Russians have given their teaching profession.

A Standard For Faculty Pay

Earlier editorials in this series have outlined various ways American business can help relieve the financial plight of our colleges and universities. They have suggested that private contributions to higher education should average at least $400 million a year over the next ten years if faculty salaries are to be raised to adequate levels and our colleges are to be able to meet increasing operating costs.

Another standard for raising faculty salaries proposed by an American businessman is this: "When a teacher's income gets up to a point where you will suggest to your boy that he ought to give some thought to teaching as a profession, then we may be approaching the right figure."

Russia clearly has set her teaching salaries well above the "right" figure. We are nowhere near it. What this adds up to is that the Communists — not we — have become the shrewd capitalists in the vital field of education.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

Donald C. McGraw
PRESIDENT

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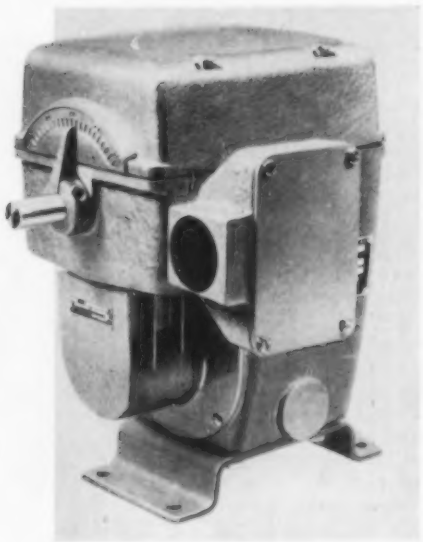
NEW COMPONENTS AND MATERIALS

Instrument-actuated Motor Operates Control Elements



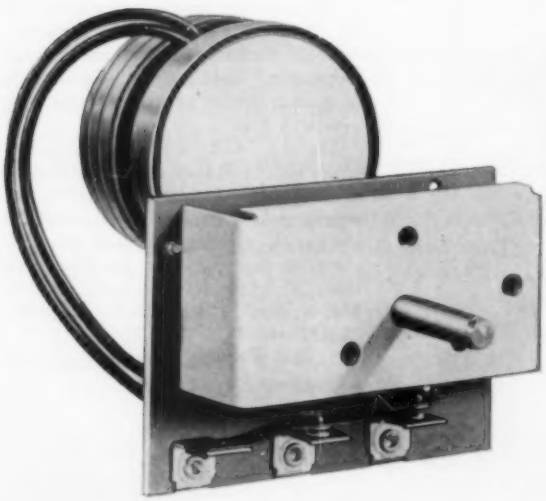
Guided by instrument-generated signals, this motor can operate a wide range of control elements: valves, dampers, louvers, rheostats, adjustable transformers, mechanical speed changers and burner firing controls. Two models, each having two-position, floating or proportional control systems, are available in various speeds and torques. Series 831E2 has a rated output torque ranging from 1.5 to 31.2 ft-lb. Series-831E1 torque rating ranges from 3.1 to 62.5 ft-lb. Stall torques for both series are a minimum of twice the rated torques.

The motor positions final control elements over full rotation of driveshaft. The two-position and floating-control models can be adjusted for 35 to 335°-rotation and the proportional model for 35 to 100°-rotation without loss of reversing rotation. An external relay permits floating model to be made unidirectional, or arranged for reversing, for more than one complete revolution of output shaft.

"Coasting" of the motor is negligible, the manufacturer claims, thus eliminating hunting in proportional control. Overtravel protection is provided for the proportioning slidewire contractor so that disengagement takes place if travel limits are exceeded.

Housing of the 30-lb motor is die-cast aluminum, with a removable cover for access to terminal block, limit switches, slidewires, resistor and capacitor. Voltage and frequency of the motor are 115 or 230 v, 50 or 60 cps, or 115 v, 25 cps. Price, $200; delivery, 3-4 wk. **Brown Instruments, div. Minneapolis-Honeywell Regulator Co., Wayne and Windrum Ave., Philadelphia 44.**

Circle 1, inside back cover



Interval Timer for Ranges Up to 6 Hr.

This timer was designed for appliance and commercial markets. The device can be supplied with a variety of circuit arrangements, an audible signal, or a holding mechanism.

The timers use a berryllium-copper switch mechanism with pure-silver contacts. A single-blade design is used, with contacts an integral part of the terminals. A jump cam governs snap-switch action.

The interval timers have a time range of 1, 2 and 4 hr and are supplied with a 3-w, slow-speed motor. Voltages: 24 v, 120 v, 240 v; 50 or 60 cps, ac only. Dimensions: $2\frac{3}{8}$ x $3\frac{3}{8}$ x $2\frac{5}{8}$ or $3\frac{1}{4}$ in. **Paragon Electric Co., Two Rivers, Wis.**

Circle 2, inside back cover

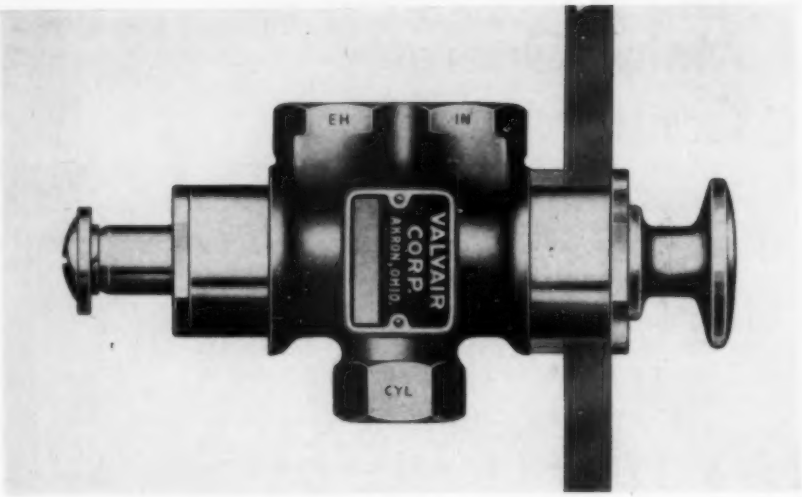
CONTINUED ON PAGE 102

Knob-controlled, Panel-mounted Valves

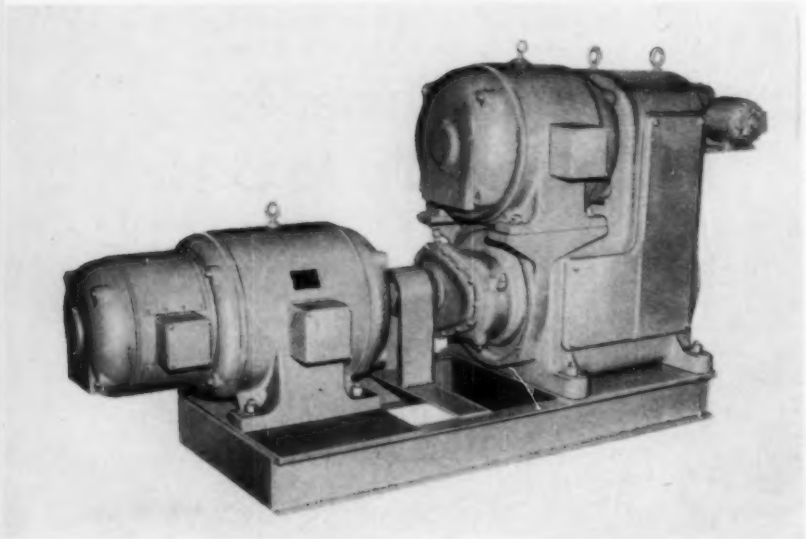
These valves are for up to 200-psi pneumatic and hydraulic, or vacuum, service. One-piece body is Navy M bronze, stem is chromium-plated stainless. Valves for pneumatic service are fitted with molded Hycar packings. O-rings are used for hydraulic or vacuum service.

Flow area through the valve is said to be equal to nominal pipe size. Valves are positioned in panel holes with a spacer and securely mounted by a flanged end bearing. Choice of spacers and special adapters permits use of various-size valves in the same panel.

Valves are available in two, three and four-way types, $\frac{1}{4}$ through $\frac{3}{4}$ in. NPT, fitted for manual or spring return. Standard max panel thicknesses range from $\frac{5}{8}$ in. for the $\frac{1}{4}$-in. valves to $1\frac{1}{8}$ in. for the $\frac{3}{4}$-in. size. **Valvair Corp., 454 Morgan Ave., Akron 11.** **Circle 3, inside back cover**



Control Motors by Varying Frequency



All sizes of ac motors and gear motors are controlled in unison and in proportion from this current-frequency changer, which allows speed variations up to 5:1. System is available for either manual, remote or automatic control.

The unit consists of a frequency changer driven by a mechanical variable-speed drive of either open or enclosed design. Applications include synchronizing interrelated equipment, splitting the drive load on conveyors and converting machine tools from constant to variable speed. **Electra Motors, Inc., 1110 Lemon St., Anaheim, Calif.**

Circle 4, inside back cover

CONTINUED ON PAGE 104

When the pressure's on...

Bridgeport
DURONZE*
is the choice
*Aluminum Silicon Bronze

Superior wear resistance and good machinability make Bridgeport Duronze 707 (Aluminum Silicon Bronze) an ideal material for many products.

Take, for example, its use by Chicago Pneumatic Tool Co., New York, N. Y., in the oil pump gears used in their rotary portable and stationary Class "P" compressors.

These gears pump the lubricating oil which seals rotary compressor vane clearances, lubricates vital parts and also cools the air during compression. In meeting the precise requirements of this job, Duronze's combination of high strength, wear resistance and machinability are equally important advantages.

In the annealed condition, in which it is generally supplied, Duronze has an average tensile strength of 90,000 lbs. per square inch. Its endurance limit is over twice that of Naval Brass and it is generally superior in corrosion and wear resistance.

Duronze is only one of Bridgeport's complete line of copper and brass alloys in sheet, rod, wire and tube, designed to help you meet a wide variety of product and production applications better, faster and more economically. To help you in choosing the right alloy for your specific needs, you can expect and get experienced assistance from your Bridgeport Salesman and from the Technical Staff behind him. For prompt service, give your local Bridgeport Sales Office a call today.

matched Bridgeport Brass Alloys to your job

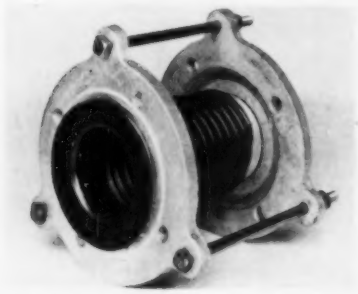
BRIDGEPORT BRASS

Offices in Principal Cities • Conveniently Located Warehouses
Bridgeport Brass Company, Bridgeport 2, Connecticut
In Canada: Noranda Copper and Brass Limited, Montreal

Flexible coupling . . .

for ½ to 30 hp achieves positive power transmission of the rated load by matching the gear teeth of the end fittings with gear section of rubber tube. In six basic hub sizes with rubber variations to increase respective torque capacity for each hub size. Under severe loads, rubber tube section expands to permit end fitting to slip, minimizing damage to either shaft or motor bearings. Rubber section can float laterally between two captive end fittings, providing driving-load distribution similar to that of a universal joint. **Guardian Products Corp., Coupling Div., Dept. A-13, 1215 E. Second St., Michigan City, Ind.**

Circle 5, inside back cover



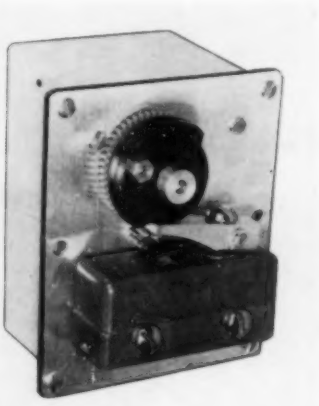
Molded Teflon bellows . . .

is said to have twice the burst strength and 20 times or more the flex life of bellows machined from Teflon cylinders. Dynamic working pressures to 120 psi, full-vacuum service, bending deflection to 70° and axial movement to 2 in. or greater are some of its characteristics. Withstands temperatures to 450 F. Bellows is non-aging, noncontaminating. Nonadhesive characteristics inhibit build-up of deposits. **Resistoflex Corp., Roseland, N. J.**

Circle 6, inside back cover

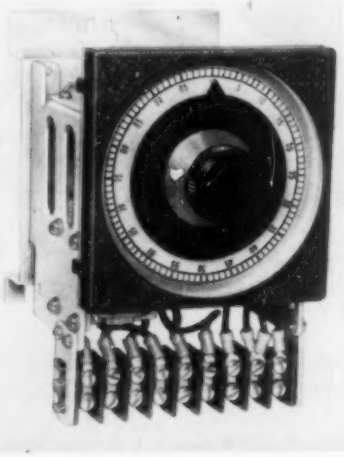
Sequence timer . . .

with switching capacity of 10 amp at 115 v dc or 15 amp at 115 v ac, has a driving motor drawing only 8 milliamp at 6 v dc. High capacity and low draw make the timer suitable for remote instrumentation where good battery life is mandatory. Employs a heavy-duty cam-actuated



switch of magnetic quench type. Speed regulation is ±1% over a voltage shift of ±50%. Actuating cam is exposed through a range of 0 to 180° for a wide selection of timing intervals. Driving motor is totally enclosed. Size, 2½ x 2 5/16 x 2⅞ in. Weight, 8.35 oz. **Brailsford & Co., Inc., 670 Milton Rd., Rye, N. Y.**

Circle 7, inside back cover



Add-subtract counter . . .

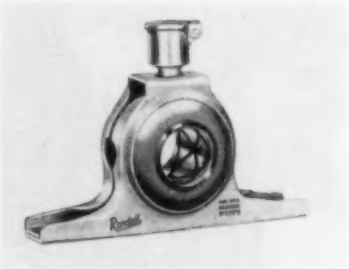
provides automatic control for conveyor or inventory systems, automatic storage hoppers or any other controlled storage area. Add and/or subtract pulses may be fed to this unit in any sequence, or simultaneously, without a miscount. SPDT switches are actuated when min or max count is reached. The counter, wired for continuous count, will also receive, add or subtract pulses continuously, 100 pulses per revolution. With the max switch set at 50 on the dial, an output pulse will be obtained every 50 pulses. Special cams are available for 5, 10, 20, and 25 counts per output pulse. Contacts are 10 amp in 115 or 230-v, 60-cps models. **Eagle Signal Corp., Moline, Ill.**

Circle 8, inside back cover

Insulation for irregular shapes . . .

in tape form is a high-dielectric material used primarily to seal and build up cable splices. Conforms to irregular shapes, acts as padding-insulator to round out sharp corners. Packaged in individual metal containers, roll is 1½-in. wide x 5-ft long x ⅛-in. thick. Has average dielectric strength of 445 v per mil of thickness and can operate continuously at 160 F. Permanently plastic, it will not dry out, become brittle or excessively hard. Resists acids and alkalies. **Johns-Manville Dutch Brand Div., 7800 S. Woodlawn Ave., Chicago 19.**

Circle 9, inside back cover



Sleeve-bearing pillow blocks . . .

for shaft sizes 1 1/16 in. and 1¼ in. have graphited cast-bronze bushings and feature automatic controlled double lubrication, automatic self-alignment under all conditions, quiet, maintenance-free operation for long periods and mounting in any position. New pillow blocks are 3¾-in. high, including oiler, 5 7/16-in. long with a base 1⅜-in. wide. To meet the larger shaft dia, bearing length is 2 in. **Randall Graphite Bearings, Inc., Box 839, Lima, Ohio.**

Circle 10, inside back cover

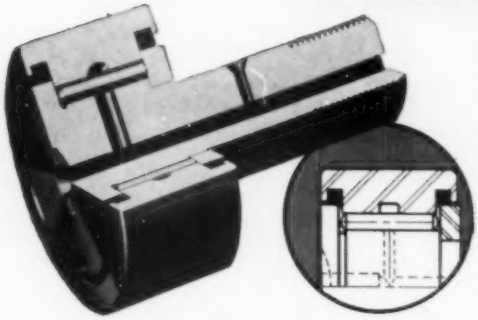
Photoconductive cells . . .

have various sensitivities, depending on illumination intensity. Resistance ranges from greater than 1 megohm in the dark and only a few hundred ohm at a 50-ft-c light level. Photocells will operate magnetic and thermal relays without intermediate amplifiers. In standard form, the cell has a sensitive area about ¾ x ¾ in.,

CONTINUED ON PAGE 106

BEARING TIPS by McGill

sealed CAMROL® bearings lock out contamination in critical cam follower applications

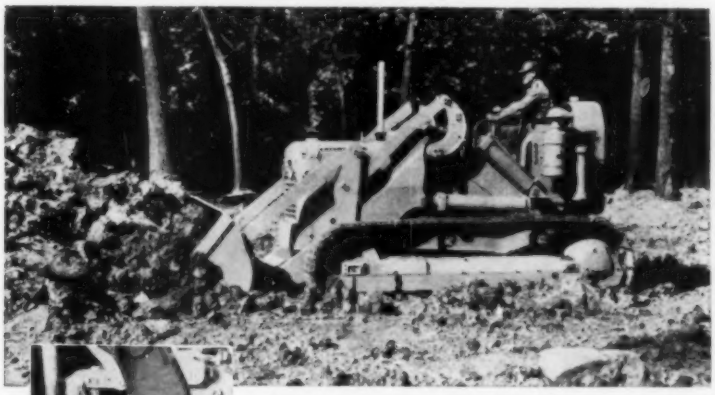


Now Sealed and Prelubricated

The new SCF series of the famous CAMROL cam follower completely seals out dirt, chips, moisture, etc. — an important advantage where the life of an ordinarily open mounted cam follower can be materially increased with adequate protection against contamination. Also the sealed bearing is pre-lubricated with provision made for easy re-lubrication, if desired, through either end of the stud.

Specially treated synthetic seals are contained in the outer race undercuts over the stud flange and roller retaining washer. For added protection, all external surfaces of the bearing are treated to provide a corrosion resistant, black ferrous oxide surface.

These same advantages are available in the SCYR sealed series Cam Yoke Roller (without stud). Specify CAMROL bearings with the built-in seals that preserve cam follower dependability in critical cam action, support or track roller application.



Built-in seals protect and preserve CAMROL® bearings from contamination in CATERPILLAR-built TRAXCAVATORS®

McGill SCF series sealed CAMROL bearings provide the cam action that positions the bucket of the No. 977 Traxcavator unit at the selected digging angle. Mounted on bell crank arms that are actuated by contact with a cam shoe on a hydraulic cylinder linkage, these bearings are operating in the open and exposed constantly to dust, dirt and moisture. External surfaces have a black ferrous-oxide finish to prevent corrosion. These sealed McGill cam followers eliminate the need for relubrication and maintenance after installation. Caterpillar uses other McGill bearings including twelve CYR series cam yoke roller bearings in the flywheel clutch.

378 sealed CAMROL® bearings guide engine blocks in INGERSOLL automatic milling machine

The sealed CAMROL bearings used in this machine, guide cylinder blocks during transfer through various milling, boring and drilling operations. The bearings, used in place of guide bars, eliminate surface scratching of the 200 to 300 pound blocks which are transferred at speeds up to 400 feet per minute. Blocks are processed at the rate of 95 per hour. Ingersoll reports freer movement, accuracy of positioning and materially longer bearing life due to the new design that seals metal chips out of the bearings.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

with a thin layer of cadmium sulfide, in a sealed glass envelope. Cells have response throughout visible spectrum and continuous max permissible dissipation in excess of 600 milliw at 68 F. Temperature range is —40 to 167 F; 240 v ac, max. **Canadian Marconi Co., 6035 Cote de Liesse Rd., Montreal, Canada.**

Circle 11, inside back cover

Hydraulic filter . . .

features low pressure drop and operates from —65 to 200 F. Filter cover, secured by retaining ring, can be removed by hand. Three models are offered to accommodate pressures to 5000 psi and flows from 15 to 90 gpm. Relief valves, pressure-drop gages and special taps are optional equipment. The filter has applications in the hydraulic, machine tool and aircraft industries. **Test Equipment Div., Consolidated Diesel Electric Corp., Stamford, Conn.**

Circle 12, inside back cover

Subminiature switch assembly . . .

is available from stock parts and tooling. Unit is packaged in a standard Size-10 Buord synchro housing of 0.937-in. OD. Standard in one to six circuits. Length is 1.319 in. for six circuits and decreases with number of circuits. Rotor is molded in Kel-F at 0.235-in. dia and has been tested at speeds from 0 to 5000 rpm. Unit has passed military specifications for temperatures from —85 to 257 F, for temperature shock, humidity, altitude, salt spray, vibration, 50-g shock with no contact bounce, fungus resistance, excluding dirt, and for being explosionproof. Use of Kel-F dielectric permits continuous operation to 350 F. **Electro-Miniatures Corp., 1060 Elm Ave., Ridgefield, N. J.**

Circle 13, inside back cover

Explosionproof switch . . .

monitors fluid pressures in severe conditions of temperature, vibration, and explosive pressure surge. Has been tested to 4000 psi at a rate of application as high as 8 million psi per sec. Functioning temperature is from —65 to 300 F. Utilizes a three-ply welded stainless steel pressure-sensing bellows and a buckling-column spring. Housing is aluminum alloy. Weight, 0.4 lb. **Aerojet-General Corp., sub. General Tire and Rubber Co., Azusa, Calif.**

Circle 14, inside back cover

Motor controller . . .

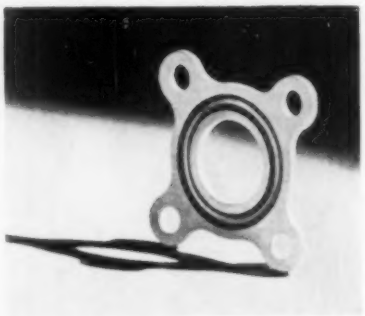
starts, stops, reverses and changes the speed of a ¾-hp shunt-wound motor, 220 to 230 v, 50 to 60 cps, single phase. Motor speed is regulated from 0 to 2400 rpm, with full torque from 300 to 2400 rpm. Controller embodies acceleration control, reverse, coarse and fine adjustment. Mounted in a 14 x 16 x 6-in.-deep steel cabinet. Control station components are in a 2 x 2 x 9-in. steel box connected to the controller with a special ten-conductor vinyl-jacketed cable 10-ft long. Controller is $275, f.o.b. Las Vegas. **Gerald K. Heller Co., 1819 Industrial Rd., Las Vegas, Nev.**

Circle 15, inside back cover

Alkyd molding compound . . .

combines surface smoothness, color and gloss, with high strength, good electrical properties and high heat resistance in a fast-cycle, low-cost process. Suited for use in radio and TV cabinets, small appliance housings, switch-gear moldings, high voltage aircraft insulation and replacements for die castings and ceramic applications. Available in molded shapes only. **Panelyte Div., St. Regis Paper Co., Trenton, N. J.**

Circle 16, inside back cover



Leak-proof static seals . . .

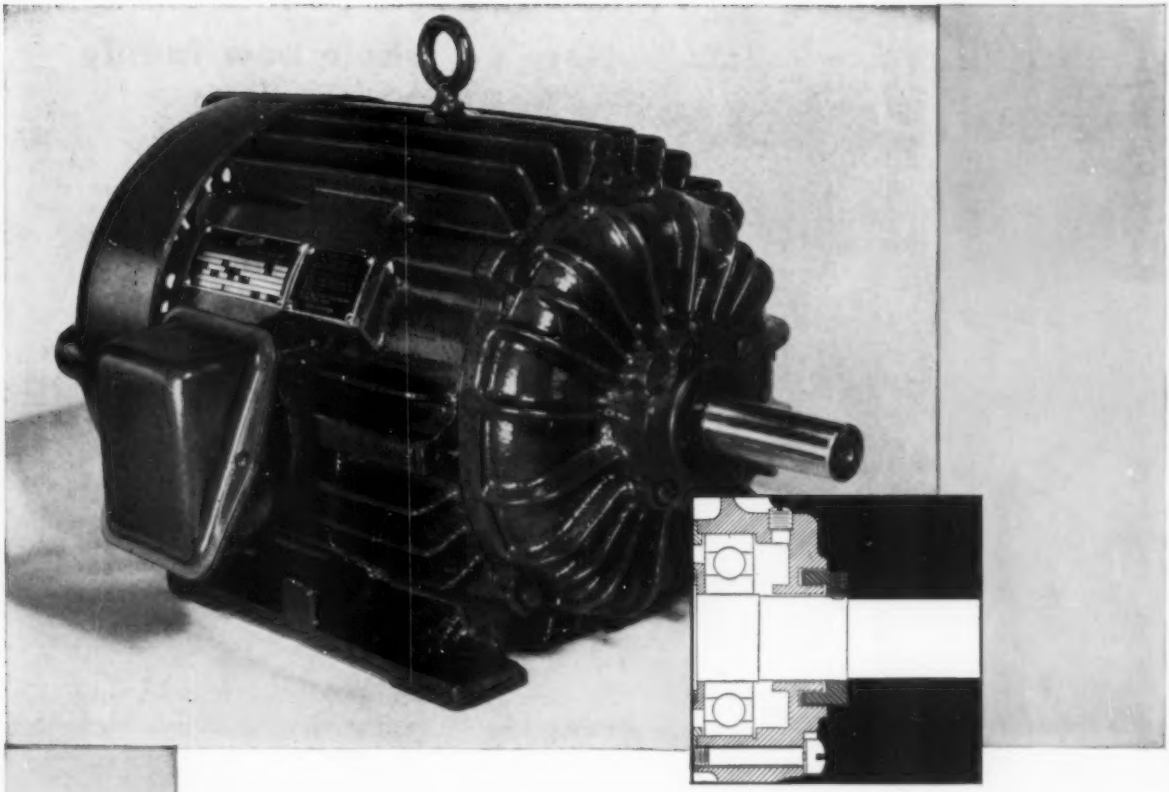
with full metal-to-metal contact are suitable for sealing a wide range of fluids at pressures from vacuum to more than 5000 psi and temperatures from —80 F to 500 F. The one-piece gasket eliminates close tolerances. Available in AN-763 flange patterns or special patterns. Can also be used as orifices, cover plates and spacers. **Stillman Rubber Co., 5811 Marilyn Ave., P.O. Box 1097, Culver City, Calif.**

Circle 17, inside back cover

Miniature switch with ¼-in. overtravel . . .

consists of two standard, hermetically-sealed miniature switches in a dust and moistureproof case and a plunger-type

CONTINUED ON PAGE 109



Securely sealed for low maintenance —

Century

TOTALLY ENCLOSED FAN COOLED MOTORS

When motor maintenance goes down, production goes up. Century TEFC Motor *protects itself* from dust, grit, chemical fumes, moisture. Shaft openings at each end are labyrinth-sealed, and there is a precision clearance between metal seal and bearing bracket.

Outside, a hose or whisk broom quickly cleans it. External fan forces jets of cooling air across the frame. Inside, vital motor parts are completely sealed off from injurious atmosphere. Factory lubrication of bearings is adequate for several years' service under normal conditions; however, whenever required bearings may be relubricated through grease plugs.

For full facts on your specific application, call the Century District Office or Authorized Distributor nearest you.

CENTURY . . . building TEFC Motors for 25 years

CE-46R

Performance-Rated®
MOTORS
1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

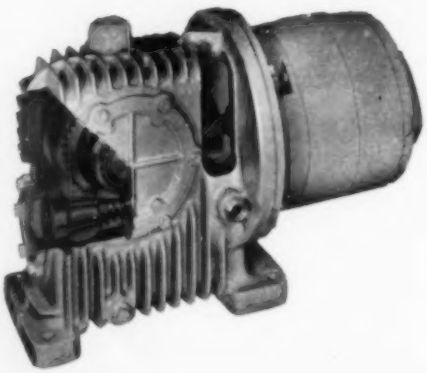
Here's a whole new family of fine GEARMOTORS by Cone-Drive Gears

MOUNT THEM ANYWHERE—FLOOR, WALL, CEILING, OR HANG THEM ON A SHAFT...

. . . there's a Cone-Drive gearmotor for every need. Look at the extensive line of space-saving, power-packed models now available. No matter whether you're faced with floor, wall, ceiling, or shaft mounting at any angle, Cone-Drive Gears has a gearmotor for the job.

It's the most versatile line available PLUS big power capacity in a really compact package. Double-enveloping worm gears, pioneered and proven by Cone-Drive Gears, are combined with a helical primary and extra-large taper roller bearings in a rugged finned housing to give you a power package without equal. You can select any model in any of 27 standard output speeds (7.3 to 525 rpm at 1750 rpm input) in capacities from 1 through 25 horsepower.

Best of all, Cone-Drive gearmotors are priced right down with units that can't deliver nearly as much performance and versatility. Check your nearby Cone-Drive representative or write today for new Catalog 57 containing complete specifications.



Cutaway view of typical Cone-Drive gearmotor illustrates use of double-reduction gear train for increased output power. Note also large taper roller bearings and heavy-ribbed housing.

CONE-DRIVE GEARS

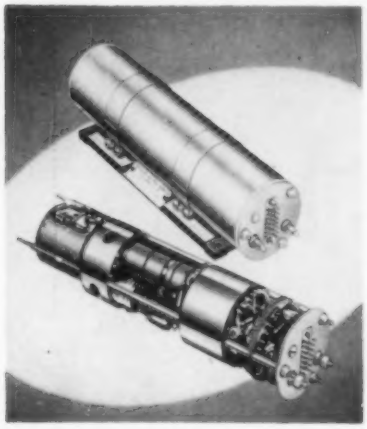
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

Division Michigan Tool Company

7171 E. McNichols Road • Detroit 12, Michigan

actuator. Actuator is spring-loaded; operating force can be adjusted to meet individual requirements. Meets military specs for standard atmospheric environmental conditions, shock and vibration. Incorporating any number of standard hermetically sealed miniature switches and an actuator, this unit can be applied to solve difficult switching problems in many fields. **Haydon Switch, Inc., Waterbury 20, Conn.**

Circle 18, inside back cover



Voltage monitors . . .

reduce normal telemetering and recording-system errors from 4 or 5% to 0.04% or less. The servomechanism accepts analog signals from sensing devices. Output is provided by potentiometers, synchros or coded disks. These are shaft driven through a precision gear train at a ratio of 100:10:1 with respect to one another. A typical configuration measures 2¼ x 6 in.-long. Repeat accuracy as close as 0.005% has been achieved over operating periods of many hours. **G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.**

Circle 19, inside back cover

Remote bulb-temperature control . . .

is built with micrometer adjustment to control over wide ranges where explosive vapors or gases are present. Composed of two integral assemblies: a remote-bulb thermal device, and control head with connecting capillary tube of varying lengths. The remote bulb is exposed to the source to be controlled. Head compensation is standard and is effective from −65 to 160 F. Models are available with adjustable range spans of −150 and 650 F with on-off differentials of approximately 1 and 2 F. Approximate weight, 4.5 lb. Switches are SP in any one of three stand-

(Continued on page 110)

You don't need a light touch to keep from stripping threads

...use HELI-COIL® Screw-Thread Inserts

Precision-Formed Stainless Steel Wire Inserts Produce Permanent Threads in Tapped Holes.

No need to worry about too much load on tapped threads when you use *Heli-Coil* Inserts. They withstand excessive torque and, even in soft metals, bolt will shear off before female threads strip. Thread life is increased . . . corrosion, seizing and galling eliminated. *Heli-Coil* Inserts allow designers to use standard bosses, lighter materials, shorter and fewer fasteners—save time, space, weight and assembly costs. Mail coupon for complete data. Also ask for information on the *NEW* Screw-Lock Inserts which give all benefits of the regular insert *plus* an internal lock. Use instead of lock nuts, lock wiring, etc.

*Reg. U.S. Pat. Off.

HELI-COIL CORPORATION

A Division of Topp Industries, Inc.

HELI-COIL CORPORATION

612B Shelter Rock Lane, Danbury, Conn.

☐ Send me design manual on *Heli-Coil* Screw-Thread Inserts
☐ Send me design manual on *Heli-Coil* Screw-Lock Inserts
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IN CANADA: W. R. WATKINS CO., LTD., 41 Kipling Ave. S., Toronto 18, Ont.

Gast rotary reversible
No. 6 Air Motor delivers

TWO HORSEPOWER

. . . weighs only 17 pounds

Here's compact, light-weight power—offering many advantages as original equipment on your products! With the new 2 h.p. Model 6AM added to the line, Gast offers rotary air motors in five popular sizes from the 1/20 h.p. Model 1AM to the 4 h.p. Model 8AM.

To fulfill designers' needs, Gast also offers standard variations on some models, including foot or flange mountings for vertical or horizontal applications with direct or gear drive . . . special reversible rotation, etc. Well adapted for plant use or as original components, Gast Rotaries are *explosion-proof, variable in speed, burn-out proof* even when stalled—and low in first cost!

Wherever compressed air is available, they're a power source worth investigating! *Write for Model 6AM Bulletin* 657—or specify size that interests you. *Request "Application Ideas" Booklet too!* — Gast Manufacturing Corp., P.O. Box 117 -V, Benton Harbor, Michigan.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

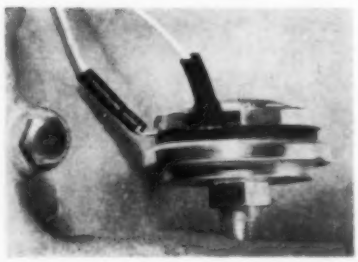
SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

ard types, normally open, normally closed or DT with no neutral position. Rated for 15 amp at 115 or 230 v ac. Suitable for 180-F ambient temperatures. **United Electric Controls Co., 79 School St., Watertown, Mass.**

Circle 20, inside back cover

Silicon rectifier junctions . . . rated at 200 amp rectified-dc output current in plate input voltages of 100 to 400 v are designed to integrate with the heat exchanger into one small package, permitting quick installation. Hermetically sealed in an anodized, cast-aluminum housing highly resistant to corrosive conditions. Air-cooled unit is designed to withstand shock and vibration. **International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.**

Circle 21, inside back cover



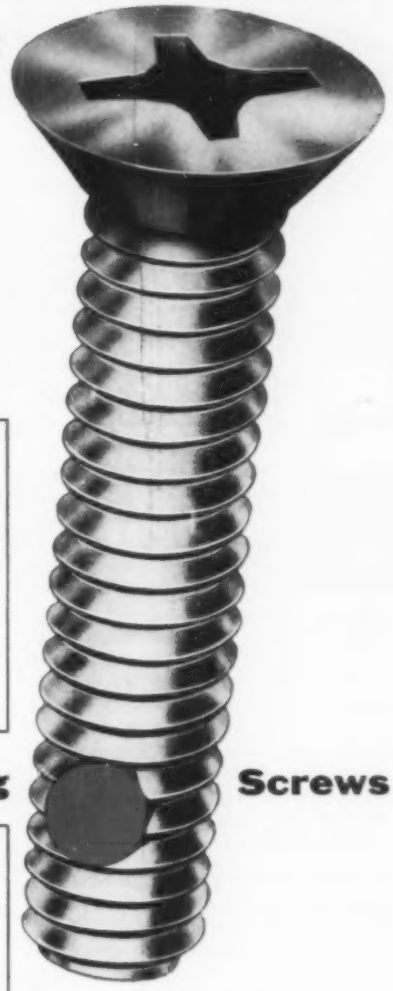
Vacuum switch . . . for internal combustion engines has a dashboard warning light that automatically signals inefficient engine operation caused by a reduction of manifold air pressure. Primarily for gasoline and diesel-powered engine equipment that uses a positive-type, paper-element air cleaner. Completely enclosed in a corrosion-resistant case, constructed to withstand severe engine vibration. Electrical switch is SPST snap-acting type with silvered contacts. Can be mounted in any position on the engine by a ¼-in.

(Continued on page 114)

Continental has the cure for vibration "headaches"

the one-piece locking screw that won't work loose

HOLTITE® NYLOK Screws and Bolts are one of the many progressive ideas in fasteners pioneered by Continental. These one-piece, self-locking fasteners with the Nylon insert eliminate the need for lock washers, jam nuts, wiring, and similar devices. If you have fastening problems (like the applications below), for which Nylok is the practical solution, you can start now to save assembly dollars, and give your product a definite competitive advantage.

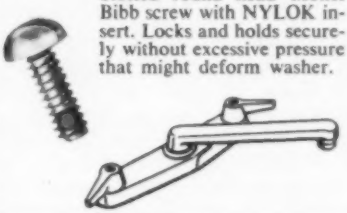


BEAT VIBRATION, KEEP CHAIN SAWS "ON THE JOB"

Several styles of machine screws with NYLOK inserts are used. Stay tight, ending previous customer complaints of high maintenance costs.

HOLD FAUCET WASHERS FIRMLY AT CORRECT ADJUSTMENT

Slotted round head Monel Bibb screw with NYLOK insert. Locks and holds securely without excessive pressure that might deform washer.



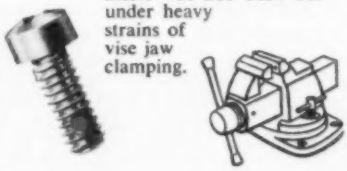
HOLTITE® NYLOK® Self-locking Screws

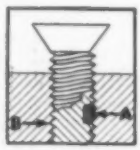
STAY TIGHT UNDER CONSTANT STRESSES IN METAL CHAIRS

Oval head machine screw with NYLOK insert, used in telephone operators' chairs, solved problems of excessive maintenance, clothing damage, etc.

WITHSTAND REPEATED SHOCKS IN VISE JAW INSERTS

Phillips fillister head machine screw with NYLOK insert will not back out under heavy strains of vise jaw clamping.





HERE'S WHY HOLTITE NYLOK® LOCKS SECURELY

Resilient nylon plug (A) sets up a lateral thrust, smoothly wedges mating threads together (B). All locking action is on threads: head is not stressed. Locking is positive . . . seated or unseated.

CHECK YOUR ASSEMBLIES. Find out where Continental cost-saving ideas, like Nylok, can cut your assembly costs. Continental Assembly Specialists are fully qualified to analyze your operations and advise which fasteners — *standard or special* — can save you most. For prompt service, write or phone: Continental Screw Co., 452 Mt. Pleasant St., New Bedford, Mass.

One piece — no separate parts
Can be removed and replaced
Interchangeable — reusable
Locks seated or unseated
Acts as seal for gases, liquids

CONTINENTAL
HOLTITE FASTENERS

HOLTITE PHILLIPS AND SLOTTED HEAD
WOOD • MACHINE • TAPPING • THREAD CUTTING • SEMS • NYLOK
HY-PRO PHILLIPS INSERT BITS AND HOLDERS

(Advertisement)

Facts to consider when you're buying

Chromate Conversion Coatings

for Corrosion Protection, Paint Base, Decorative Finishing

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002″ max.) gel-like, complex chromate film of a nonporous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

If your company is manufacturing or buying parts or complete assemblies made from or plated with any of the more common non-ferrous metals—zinc, cadmium, aluminum, magnesium, silver, copper, brass or bronze—you've probably already run up against the question of finishing these surfaces with a chromate conversion coating. These coatings are used to protect against corrosion, or to provide a base for paint or to provide a decorative finish for sales appeal or shelf life. Since chromate conversion coatings represent a relatively new means of obtaining these finishes, this digest of facts to consider may be of value to you.

1. THE COATINGS THEMSELVES. There are many brands on the market. All are similar in many ways. Each, of course, offers its own specific advantages and these may relate to operating techniques, performance under actual use conditions, cost, availability, etc. Naturally, you'll want to choose a coating that is widely known and accepted under both military and civilian specifications.

2. THE COMPANY BEHIND THE PRODUCT. Is it a reliable, established organization? Does it offer experienced technical service, both from the field-engineering organization as well as the home office and laboratories? The man who sells and services your installation should be thoroughly familiar with not only chromate conversion coatings and their applications, but also with the characteristics and performance of related finishing operations such as precleaning, electroplating, painting, etc. This is most important since all steps of the finishing cycle must be functioning properly for the satisfactory performance of the ultimate finish produced.

3. AVAILABILITY OF THE PRODUCT. Ideally, of course, the material should be readily available to you from nearby warehouses to avoid time loss in long distance shipping and to provide emergency service, should the need arise.

4. COST. Naturally, the initial price of the material is important to you. However, just as you consider ultimate cost when you are buying mechanical equipment, ultimate cost must be considered for these finishing chemicals. So, it will pay you to investigate consumption costs, labor costs and the other factors which go into the determination of ultimate cost. Further, cost alone gives no indication of product performance, so careful attention must be given to the purpose the finish must serve and the value that finish will add to your product.

5. FACILITIES FOR RESEARCH AND DEVELOPMENT. Perhaps the existing types of chromate conversion coatings do not include a compound that will accomplish exactly what you wish. Then, it is important to deal with a supplier who has adequate research and development facilities available to work with you to produce a material to meet your needs. Naturally, such a project is seldom completed overnight. But, with complete cooperation and confidence from both you and your supplier, chances are a satisfactory program can be completed.

These are the concepts of sales and service on which we, Allied Research Products, Incorporated, have developed and marketed the line of Iridite chromate conversion coatings . . . superior product performance, complete sales and technical service, easy product availability, economical cost, extensive research and development facilities. No doubt you are familiar with our line and have seen this trademark—

IRIDITE®

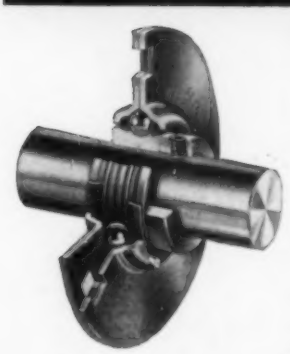
—in our advertising, technical literature or on shipping containers in your plant. Remember this trademark when you're buying or investigating chromate conversion coatings for your company. It's your assurance of quality, economical products from a reliable and established company, skilled sales and technical service from both our home office and a national network of representatives, immediate availability from warehouses in strategic industrial areas and our willingness to work with you to develop new finishes to meet your needs, should the present line fall short.

For complete information on Iridite chromate conversion coatings, write today for your free copy of our technical data file. Or, for immediate advice, call in your Allied Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

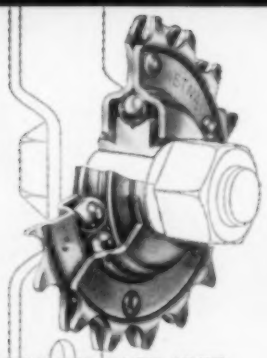
ALLIED RESEARCH PRODUCTS
INCORPORATED
4004-06 E. MONUMENT STREET • BALTIMORE 5, MD.

Manufacturers of Iridite chromate conversion coatings for corrosion resistance, paint systems, final finishing of non-ferrous metals; ARP Plating Brightener & Chemicals. West Coast Licensee—L. H. Butcher Co.

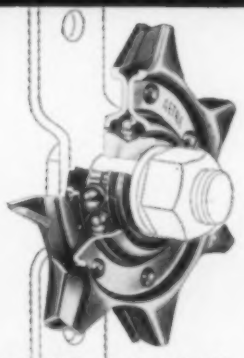
AMERICA'S MOST COMPLETE LINE



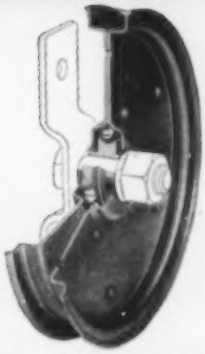
ADAPTER UNIT



SPROCKET IDLER UNIT
(Single pitch chain type)

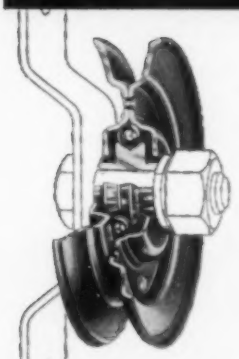


SPROCKET IDLER UNIT
(Detachable link chain type)



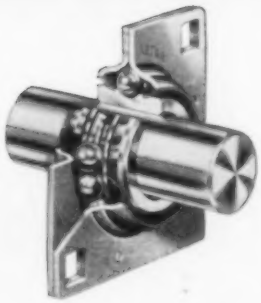
FLAT BELT IDLER UNIT

OF LOW-COST, PRE-LUBRICATED



V-BELT IDLER UNIT

DISC HARROW UNIT



GRAIN ELEVATOR UNIT

The Economy Line That Lets You Put MORE Ball Bearing Efficiency to Work in MORE Places

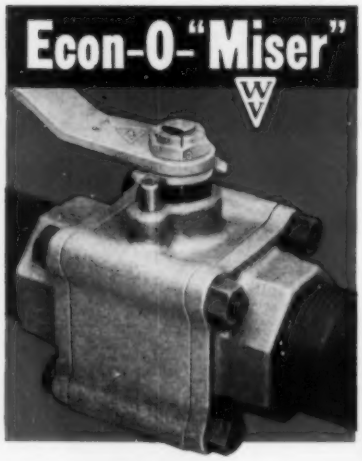
BALL BEARING *Package* UNITS

Designed and built-to-be-installed-and-forgotten these permanently lubricated, sealed-for-life bearing units require no re-lubrication, no maintenance of any kind. Factory assembled, they combine bearing, seals and housing in a single, compact, easy-to-install *package* that saves time on equipment assembly lines—assure longer, trouble-free performance to equipment users.

Catalog AG-57 gives complete specifications. Write for it on your company letterhead—see how, with minimum or no engineering alterations, these inexpensive bearing units can be adapted to your current or projected equipment designs. Aetna Ball and Roller Bearing Company, Division of Parkersburg-Aetna Corporation, 4600 Schubert Avenue, Chicago 39, Illinois.

Aetna

Anti-Friction Consultant to Leading Original Equipment Manufacturers Since 1916



Worcester's New Econ-O-"Miser" Ball Valve* is BOTH

VALVE and UNION

The costs of a union and installing it are eliminated. Add to this the longer operating life of the Econ-O-"Miser", the time and materials savings of *in-line maintenance*, and you get performance unmatched by *any* valve at *any* price.

The Econ-O-"Miser" is available in Bronze, Aluminum, Aluminum Bronze, Forged Carbon Steel, types 303 and 316 Stainless Steel. Seat and seal materials available: Teflon, Buna-N and Neoprene (others available on request.)

The many combinations of body and seat seal materials allow handling of exceptionally wide range of media.

Other Outstanding Features

- Compact for ease of installation
- Positive leakproof shut-off
- **In-line maintenance** permits quick, easy inexpensive repairs
- Two-way flow allows application of pressure or vacuum to either side of valve
- Quarter turn operation — readily adaptable to remote control
- Visual determination of OPEN — CLOSED positions — No manual check needed
- Round flow through the valve — minimum pressure loss and turbulence
- "Wiper-action" of resilient seat against ball eliminates abrasive wear due to foreign materials in media . . . assures leak-proof seal . . . long operating life

* Pat. Pending

Write for full particulars

WORCESTER VALVE CO., Inc.

18 Parker Street, Worcester, Mass.

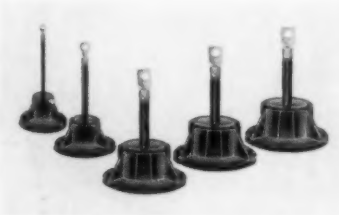
male-pipe threaded boss. Sensing diaphragm is oil-resistant, capable of accurate calibration from —40 to 250 F. All switches are factory-adjusted in a range of vacuum levels. **Fulton Sylphon Div., Robertshaw-Fulton Controls Co., Box 400, Knoxville 1, Tenn.**

Circle 22, inside back cover

Nameplates without artwork . . .

are possible using standard blank sizes and lettering. Photochemical nameplates are similar in appearance to etched plates. Letters are aluminum on a black background. Plates adhere to any surface with a special adhesive. Delivery is about 1 wk. **Henry G. Dietz Co., 12-16 Astoria Blvd., Long Island City 2, N. Y.**

Circle 23, inside back cover



High-current silicon rectifiers . . .

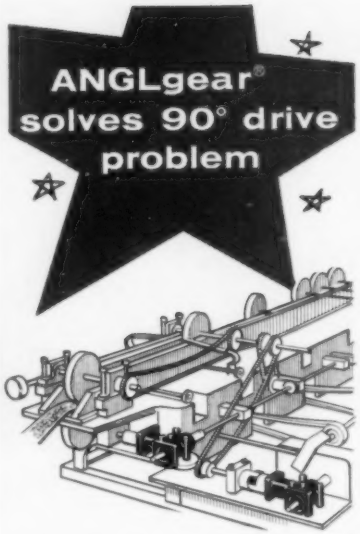
are available in five types in current ratings from 20 to 200 amp dc with peak inverse voltage range from 50 to 300. Designed for high-temperatures, high-efficiency applications. Operates efficiently to 212 F ambient temperatures. Positive or negative base polarity is available to simplify circuit connection. Features include compact size, and shock and vibration-resistant construction. **Sarkes Tarzian, Inc., Rectifier Div., 415 N. College Ave., Bloomington, Ind.**

Circle 24, inside back cover

High-speed, lightweight diesel . . .

makes it practicable to harness diesel power to small agricultural, marine and industrial equipment. These English-built engines weigh from 243 lb for the single-cylinder to 503 lb for the four-cylinder. Hp ranges from 6.25 to 25. The two-cylinder model, weighing 329 lb, develops 12.5 hp; the three-cylinder, weighing 439

(Continued on page 119)



Simplified drawing based on photo shows ANGLgear application on Texas Inking Machine Co. belt finishing machine. Change from exposed miter gears to ANGLgears solved noise, lubrication and safety problems.

Texas Inking Machine Co., Stafford, Tex., recently developed a machine that automatically polishes and dyes the edges of leather belts. The design involves several 90° drives, and on early models these created problems. "We used exposed miter gears which gave us constant trouble in regard to noise, disengagement, lubrication failures, and the danger of entangling the women operators used so extensively in this industry," Texas' chief engineer recalls. "Now — with ANGLgears—we have a quiet, safe operation and complete confidence in our machine."

Perhaps ANGLgear can solve a 90° power takeoff problem for you. Completely enclosed and permanently lubricated, ANGLgears are available from stock in ⅓ to 5 hp ratings, with 2 or 3-way shafting, and 1:1 or 2:1 gearing.

See our literature in Sweet's Product Design File or contact your local distributor.

AIRBORNE®

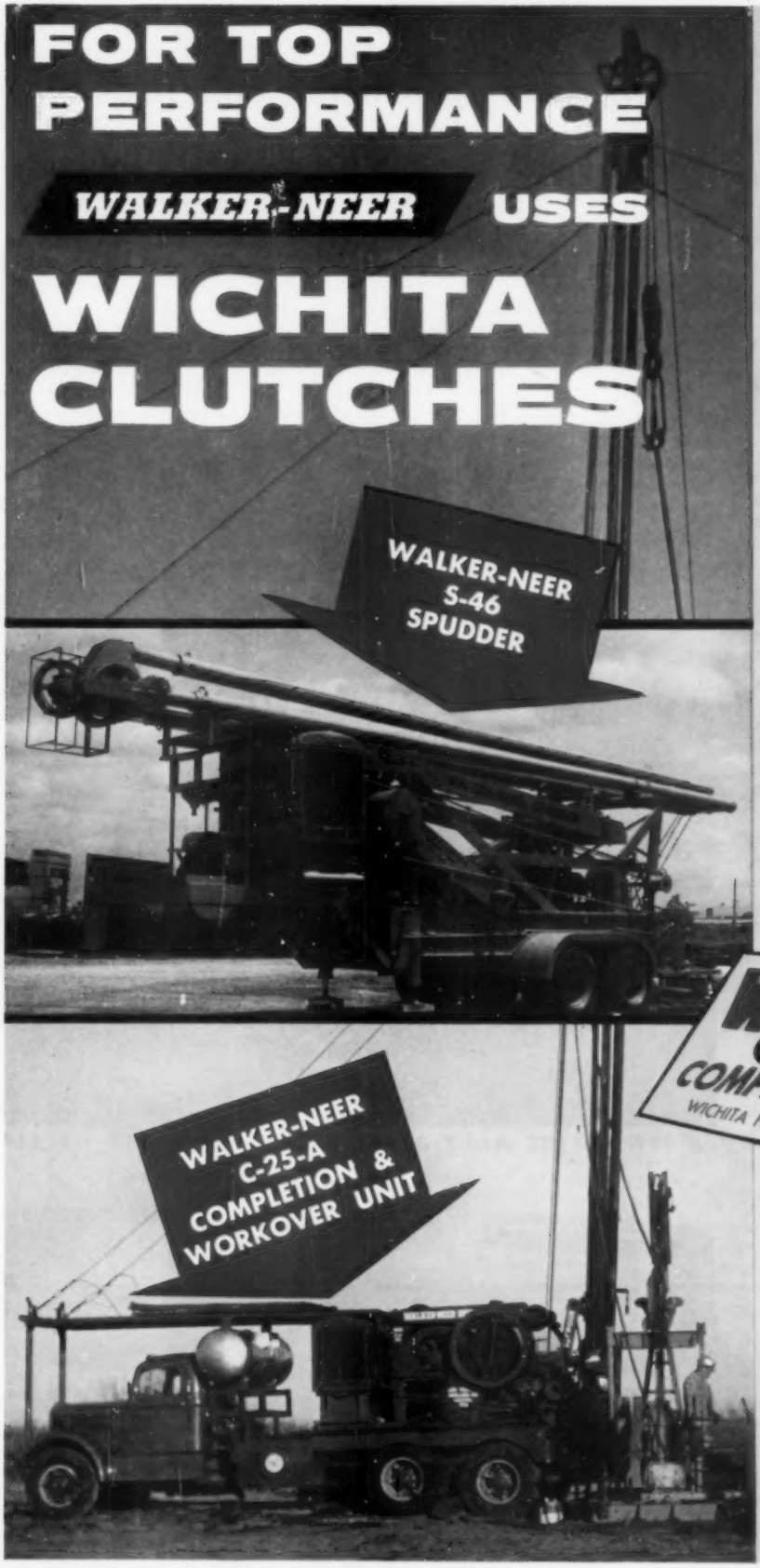
AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY

FOR TOP PERFORMANCE

WALKER-NEER USES

WICHITA CLUTCHES



"Simple design, efficient operation"

States: Roy Sanders
Sales Manager

"The Wichita Air-Tube Disc Clutches on our equipment have met a wonderful reception from our customers. They like the simplicity of design and the efficiency of operation. Another big feature is that our customers like excellent service available on Wichita Clutches throughout the United States and some foreign countries." This simple, compact, trouble-free Wichita Friction Clutch utilized by Walker-Neer combines all of the advantages inherent in air operation, such as: convenient remote control, small manual pressure required for full torque, smooth starting and quick engagement. It is engineered to give longer service, at a lower operating cost, with very little maintenance.

FOR TOP PERFORMANCE SPECIFY WICHITA CLUTCHES

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

A Wichita Engineer is available near you for free consultation . . . Contact him TODAY!

Brahm-Laner, Inc., Detroit, Michigan
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn.
Philadelphia 44, Pa., & New York, N. Y.
Frank W. Yarline Co., Chicago, Ill.
Larry W. McDowell, Long Beach, Calif.
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Allied Transmission Equipment Co., Kansas City 8, Missouri
Norman Williams, Houston, Texas
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd. Burlington, Ontario, Canada

Made by Hadley Products Co., Inc., Marietta, O., the Electronaire filter is used in heating and air conditioning units. Features unique, permanently electrostatic thermo-plastic monofilaments. Grilles are Penmetal expanded aluminum.

They market a permanent filter with the help of expanded aluminum

Sales appeal of an Electronaire filter is permanence . . . and washability. Never needs replacing; cleans easily in water.

The retaining grilles won't rust . . . can't ever loosen . . . yet allow free passage of air and water. That's because they are shaped from remarkably versatile Penmetal expanded aluminum.

When aluminum is slit and stretched to form expanded metal, it retains its inherent advantages —gains the added features of even lighter weight, high percentage of open area and greater strength. This combination of properties offers a tremendous potential for product design and improvement. Particularly where grilles or guards are required.

So, take advantage of Penmetal expanded aluminum in your designs and in your selling. But first, you ought to have a reference copy of bulletin 507 E-M. Write today.

PENN METAL COMPANY, INC.

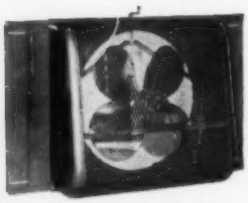
General Sales Office:
40 Central Street, Boston 9, Mass.
Plant: Parkersburg, W. Va.
District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, St. Louis, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg

METAL MARK Penmetal 1869 OF QUALITY

A FEW OF THE MANY OTHER USES OF EXPANDED METAL:

Air Conditioning Unit Grille (Berns Manufacturing Co., Chicago, Ill.)

Railroad Car Air Filter (Farr Company, Los Angeles, Calif.)



Fan Enclosure (Atlas Tool & Manufacturing Company, St. Louis, Mo.)

PM-115

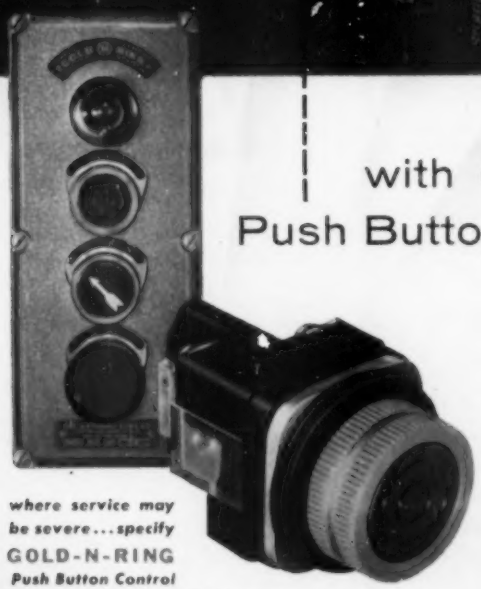
1,500,000 CYCLE

SUBMARINE TEST

Proves

1. **NO SEEPAGE**
from water, oil or coolants

2. **LONGER LIFE**
for electrical contacts



where service may be severe... specify **GOLD-N-RING** *Push Button Control Station Switches... and be sure*

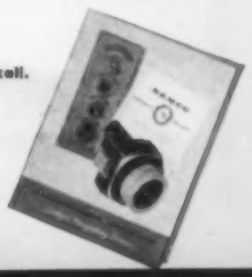
with THE NAMCO GOLD N RING SEALTIGHT Push Button Control Station Switch

This test simulated conditions much more severe than even the most demanding electrical control service would ever duplicate. Without once "coming up for air," this standard GOLD-N-RING 2-unit control switch was immersed in fluid for more than 338 hours, during which momentary electrical contact was made 1,500,000 times—at the rate of 64 cycles per minute.

This test proved the flexing qualities of the synthetic, oil-resistant diaphragm beyond a doubt. It also pointed up the "staying qualities" of the extra-large, heavy-duty, alloy silver electrical contacts.

If you are looking for a switch that is designed and built to *keep on performing* long after your machine is installed, you'll find we talk your language.

Ask us to send Catalog ECS-56—or, better yet, ask a representative to call.

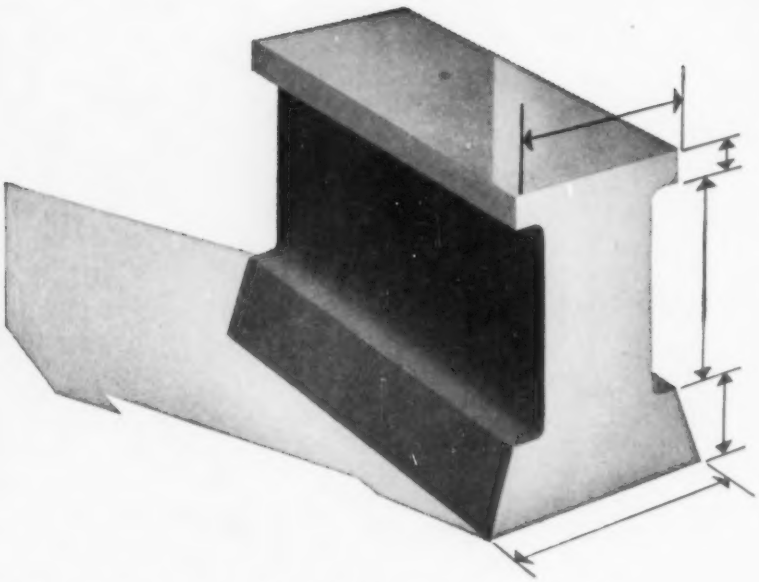


ELECTRICAL MANUFACTURING DIVISION...

National Acme

THE NATIONAL ACME COMPANY • 170 EAST 131ST STREET • CLEVELAND 5, OHIO

Cost per clamp cut from $1.06 to 58¢ with J&L hot extruded cold drawn section



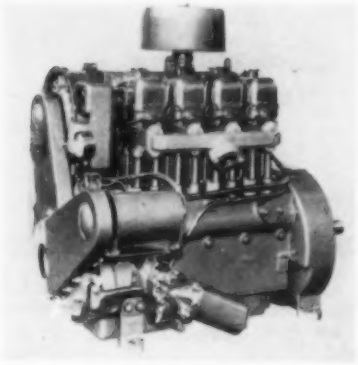
This manufacturer cut the cost of contact clamps 45% by converting to J&L extruded sections. Previous cost of $1.06 per part involved costly milling and scrap loss from cold drawn 1½" x 1" flats.

Here's how extruded sections can cut your cost:

1. Eliminate machining and finishing operations.
2. Reduce scrap losses almost to zero.
3. Eliminate cost of casting and forging intricate sections.
4. Reduce inventories because extrusions are quickly available.

Investigate this new production technique for your shape profiles—within present limits of a design which can be inscribed in a three-inch circle. Available in a wide range of carbon and alloy steels. For specialty alloy and tool steels, submit inquiry. Get complete details by writing to the Jones & Laughlin Steel Corporation, Dept. 409, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

Jones & Laughlin STEEL ... a great name in steel



lb, develops 18.75 hp. All models operate at a constant speed of 3000 rpm, more than 1000 rpm faster than comparable diesels. **Brush ABOE, Inc., 60-07 39th Ave., Woodside, N. Y.**

Circle 25, inside back cover

Miniature electromagnetic clutch . . .

normally engaged, is designed for dc operation, but will perform efficiently on full-wave rectified ac without filtering. Sizes with torque ratings are: 0.500-dia servo-mounting flange with 2 in.-oz min; 0.750 dia with 8 in.-oz; 1.000 dia with 16 in.-oz min; 1.250 dia with 32 in.-oz min. Available in standard or special units. **Autotronics, Inc., Rt. 1, Box 812, Florissant, Mo.**

Circle 26, inside back cover

Sensor unit . . .

for sorting and counting, responds to metallic and most nonmetallic materials. Within limits, it will detect a $\frac{1}{16}$-in. change of position of metallic parts. Can also be used for limiting, warning and process control and gaging when used in conjunction with a controller. Response rate is 400 ppm. Output is nominally

(Continued on page 120)

NO ONE FILTER MEETS ALL DESIGN NEEDS . . .

and Only CUNO offers you

5 DISTINCT TYPES OF FILTER MEDIA

♦ EDGE-TYPE ♦ WIRE-WOUND ♦ SCREEN
♦ FIBER CARTRIDGE
♦ POROUS METAL

consider Super AUTO-KLEAN

where filter design calls for

- ♦ **MICRONIC FILTRATION . . .** down to 40 microns
- ♦ **POSITIVE, SELF-CLEANING ACTION . . .** no "down time"
- ♦ **SMALL SIZE plus HIGH FLOW RATES . . .** 12" unit shown here handles over 50 gpm
- ♦ **LOW PRESSURE DROP . . .** less than 3 psi

All-metal construction, carbon or stainless steel.
Two-stage filtration. Lowest cost-per-gallon.

COMPLETE DESIGN-ENGINEERING SERVICE

There is a Cuno Field Engineer conveniently located in your area. To help you solve your design problems, this trained specialist offers you *more years of experience* in removing *more sizes of solids* from *more kinds of fluids.*

WRITE FOR DATA

CUNO

Send now for your free copy of Cuno Catalog No. SAK-057 containing complete engineering data. See how this high-performance filter can help your designs achieve new efficiency.

CUNO ENGINEERING CORPORATION
20012 SOUTH VINE STREET, MERIDEN, CONN.
Filtration Engineers in Principal Cities

Let us take over your inventory problem!

Immediate Delivery

ANY BORE SIZE • ANY MOUNT • ANY STROKE

CARTER
CYLINDERS

Sounds too good to be true, but here's real help for engineers and designers who need fast action on cylinders. Carter's exclusive key type locking design and simplicity of parts *makes it possible to ship cylinder orders in 24 hours or less!* Now you can have rugged, dependable, compact quality cylinders when you want them. We produce around the clock. Your order is in process *minutes after we get it.*

Service on spare parts is good too! Experienced engineers and parts stocks are located in 40 different locations in the U. S., Canada and Mexico.

PHONE SERVICE 24 HOURS A DAY

Orders taken day or night. If you need fast service call your Carter representative or the plant. LANSING, ILLINOIS, GRanite 4-3305 or CHICAGO, BAyport 1-7186. Teletype LNSG, ILL 1119X.

Complete Catalog File!

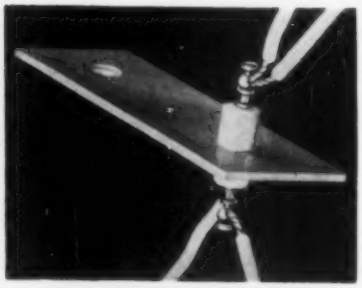
Complete bound file with ordering details for: Air Cylinders; 750 Lb. Hydraulic; 1500 Lb. Hydraulic; Clamp Cylinders; Air Valves; Built-in Valve Type Cylinders. Complete with parts data, specifications and prices. Send today!

CARTER CONTROLS INCORPORATED
2004 Bernice Road • Lansing, Illinois (Chicago Suburb)

AIR CYLINDERS • HYDRAULIC CYLINDERS • AIR VALVES
ROTARY ACTUATORS • SPECIAL CONTROLS

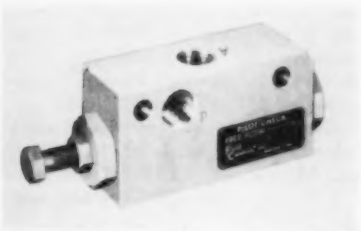
5 v dc across a 5-megohm load. Detector is particularly suitable where a light beam is not feasible, or where contact with the material should be avoided. Dimensions are 4½ x 2½ in. dia. Available from stock. Price varies from $45 to $57, depending on purchase quantity. **Autron Engineering, Inc., 1254 W. Sixth St., Los Angeles 17.**

Circle 27, inside back cover



Insulated standoff terminals . . . mount in one chassis hole. The two terminals are coaxially held at both ends of a single Teflon bushing. Available in six standard and stocked types in pin or turret-lug styles. Nominal ratings are 3500 to 5500 v. Also in a choice of eight EIA-code colors. **Sealectro Corp., 610 Fayette Ave., Mamaroneck, N. Y.**

Circle 28, inside back cover



Pilot check valves . . . for hydraulic installations feature provisions for emergency manual release. Normally used with hydraulic cylinders performing lifting or clamping operations. The valve locks the cylinder in position, preventing pressure loss caused by leakage or line rupture. Valves are spring-loaded ball-type and the manual release con-

(Continued on page 123)

FILE UP TO 3,000 DRAWINGS IN A 25" x 25" WALL SPACE

WITH *Pack* **INTER LOCK** *Files*

CONVAIR, in San Diego, saved 20% on space when they installed Inter-Lock files.

• Add individual file tubes horizontally or vertically as needed
• Cone-shaped opening for fingertip removal of drawings
• Individual indexing on file door
• Arrange in any size or shape stack to fit available space
• File single rolled drawing, or 3 or 4 individually rolled drawings, or group-roll up to 30 per tube

SAVE SPACE

Inter-Lock file tubes can be stacked right to the ceiling, or installed around existing files . . . saving space yet with complete accessibility.

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Drawings are easy to file and find . . . with indexing right on the file door, and cone-shaped front for fingertip drawing removal.

PROTECT DRAWINGS

with dust-proof, light-tight, crush-proof, and fire-resistant Inter-Lock files.

SAVE MONEY

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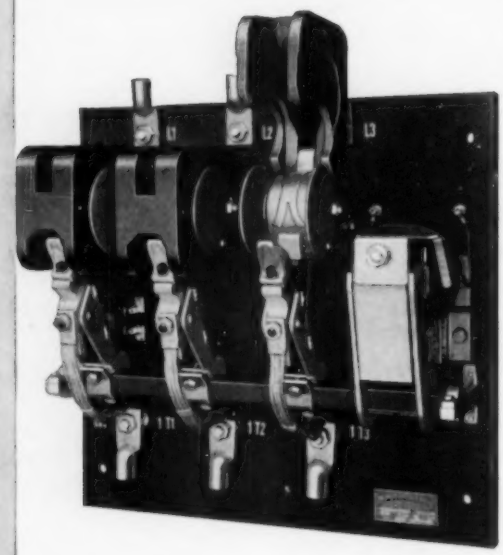
PE

HEAVY-DUTY

300-AMPERE CONTACTOR



1 *Blows out arc faster.*
2 *Speeds operating cycle.*
3 *Reduces maintenance.*
4 *Operates quietly.*
5 *Lengthens contact life.*
6 *Provides horizontal or vertical mechanical interlocking.*
7 *Combines maximum structural strength with minimum weight.*

While this mill-type contactor was specifically designed for starter, machine-tool and crane applications, it is finding use in all types of service where severe operating conditions place a premium on lasting performance.

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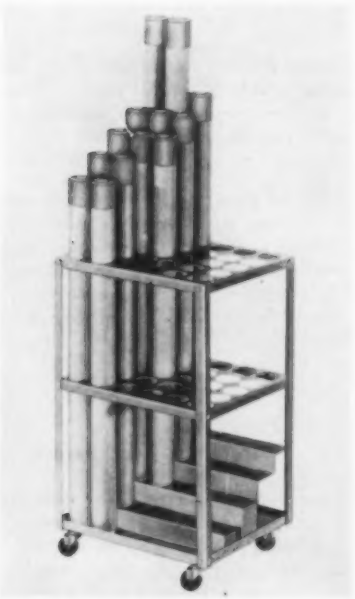
sists of a screw that depresses ball check, permitting hydraulic oil to release valve. In single and double models for oil pressures to 3000 psi. Port connections accept ¼, ⅜, ½-in. pipe sizes. **Fluid Controls, 1284 N. Center St., Mentor, Ohio.**

Circle 29, inside back cover



Mobile tubular file . . .
for plans, blueprints and charts is heavy-gage steel, finished in grey enamel. Holds contents upright in tiered, circular-tube compartments. Stepped bottom makes titles visible. Each opening is a 2½-in. dia. In 30-file capacity, price is $25; in 60-file capacity, $35. **Stacor Equipment Co., 295 Emmet St., Newark 5, N. J.**

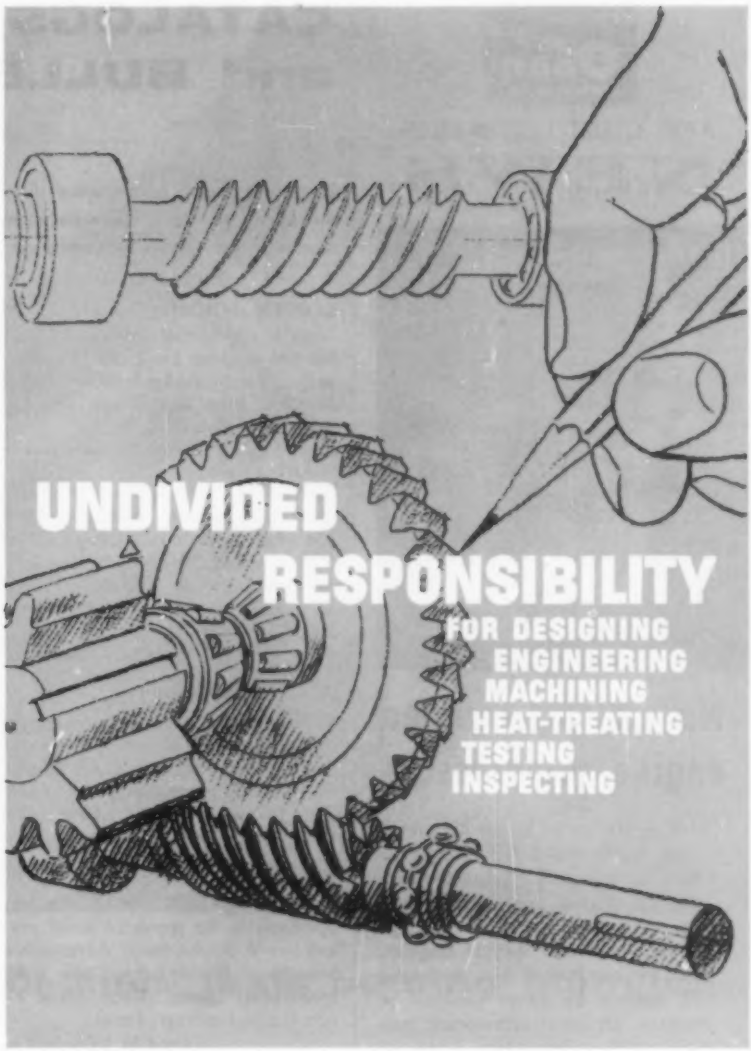
Circle 30, inside back cover

Phantom-ruled vellum . . .
has grid lines, which aid freehand drawing, lettering and dimensioning. In printmaking, grid line disappears completely. Paper has rag-content base. Controlled, uniform tooth on surface takes dense, opaque pencil lines that resist smudging and smearing. **Frederick Post Co., 3650 N. Avondale Ave., Chicago 18.**

Circle 31, inside back cover

Electronic cables . . .
come as a flat, multiconductor band. Electrical characteristics are said to be uniform from piece to piece. In all gages from No. 16 to No. 32 AWG and in any number of pairs to 4 in. wide. The flat, multiconductor band is composed of single magnetic wire, insulated, bonded into a ribbon. Conductors are readily peeled apart. **Organic Development Corp., 10052 Larson Ave., Garden Grove, Calif.**

Circle 32, inside back cover



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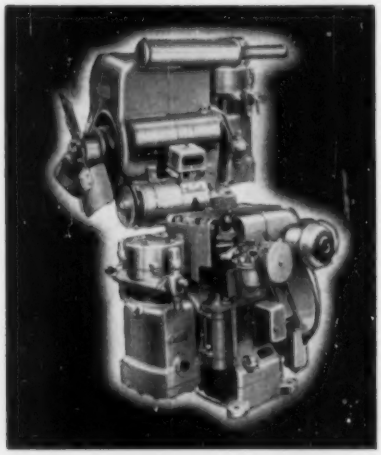
NEWS



New direct-coupled engine-compressors

Built as integrated in-line units with Onan engines direct-connected to Onan compressors. Compact, permanently-aligned and smooth-running. No troublesome belts, couplings or sheaves. Onan 4-cycle engines, built for continuous duty and long life, operate on either gasoline or Propane. Optional accessories: batteries, starters, generators, fans.

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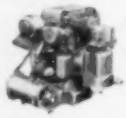
Series AJ-MC
5,000 to 15,000 B.T.U./hr. cap. One-cyl. 4.3. H.P. air-cooled Onan 4-cycle engine. 4.32 or 5.10 cu. in. compressors. R-12 refrigerant.



Series LK-MC
10,000 to 30,000 B.T.U./hr. cap. One-cyl. 6.8 H.P. air-cooled Onan 4-cycle engine. 6.28 or 8.64 cu. in. compressors. R-22 or R-12 refrigerants.

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 127.

COPPER FOIL—Booklet D-8-R, 8 pp. Suggests commercial applications of this foil and describes properties of sheet copper. Electrical applications included. American Brass Co., Copper Foil Dept., Waterbury, Conn.
Circle 33, inside back cover

HEAT EXCHANGERS—Bulletin HT-1A for fixed-bundle heat exchangers; Bulletin H-4 for copper-shell, removable-bundle heat exchangers, 6 pp. each. Standard dimensions, materials, and engineering data are given. Yates-American Machine Co., Beloit, Wis.
Circle 34, inside back cover

PLASTICS PROPERTIES—Chart CDD-5. Comparative properties of a new polycarbonate resin and other thermoplastic molding materials are outlined. Includes electrical and physical properties, molding characteristics. General Electric Co., 1 Plastics Ave., Pittsfield, Mass.
Circle 35, inside back cover

METAL POWDER PARTS—Booklet, 16 pp. Explains the powdered metal process and how it can cut costs. Advantages and limitations, design factors, and material specification charts. Reese Metal Products Corp., Lancaster, Penna.
Circle 36, inside back cover

FLEXIBLE COUPLINGS—Bulletin 99, 4 pp. Describes applications of semifloating shaft couplings with cutaway and dimensional drawings. Thomas Flexible Coupling Co., Warren, Penna.
Circle 37, inside back cover

LAMINATED PLASTICS—Stock list. Information on all copper clad grades in stock. Full details on engraving stock, standard sheet stock, 36-in. rod stock with ¼-in. to 1-in. dia. Formica Corp., 4614 Spring Grove Ave., Cincinnati 32.
Circle 38, inside back cover

FLOW REGULATORS FOR AIRBORNE EQUIPMENT—Catalog, 8 pp. Diagrams and charts explain principle of operation and how the flow regulators can be used. With cross-section and dimensional drawings. Waterman Engineering Co., 725 Custer Ave., Evanston, Ill.
Circle 39, inside back cover

PRECISION FINISHES ON METAL—Brochure, 20 pp. Reviews people and facilities available for hard anodizing and plating problems. With graphs, characteristics and properties. Anachrome Corp., 10647 Garfield St., South Gate, Calif.
Circle 40, inside back cover

FASTENERS—Catalog, 16 pp. Explains two fastener types and their driving cycles. Material, heat treatment specs, finish specs, strength properties, installation, shop practice notes and dimensional data are provided. Typical installations illustrated. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7.
Circle 41, inside back cover

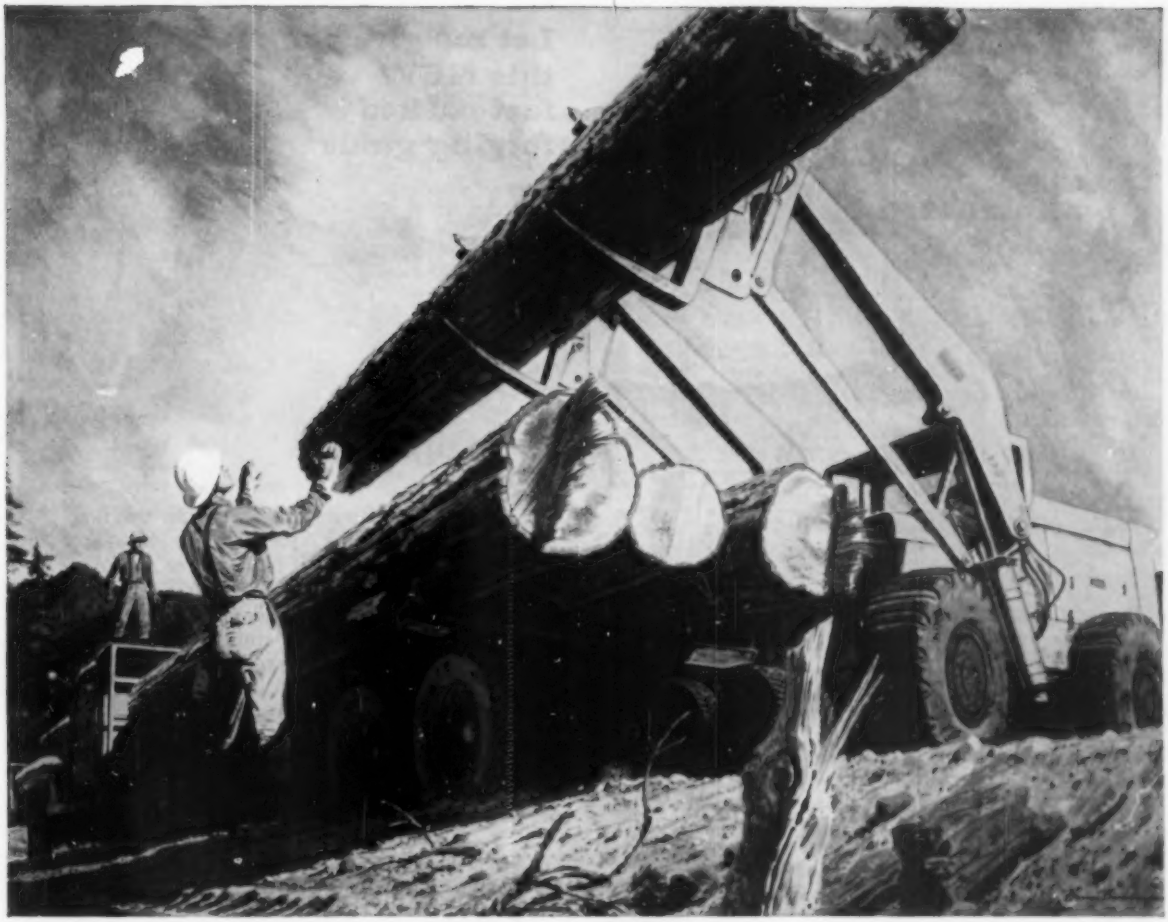
SPEED CONTROLS — Bulletin GEA-6643. 16 pp. Describes new line of packaged dc adjustable-speed drives. Includes a power-unit-data slide rule for calculating case dimensions, housepower, speed range, power-unit weight and motor-frame size. Four-color photos and diagrams. General Electric Co., Schenectady 5, N. Y.
Circle 42, inside back cover

GEARS—Brochure PG-100, 6 pp. Ranges, sizes and types of gears available. Illustrates production steps in manufacturing. Grant Gear Works, Inc., 154 W. Second St., Boston 27.
Circle 43, inside back cover

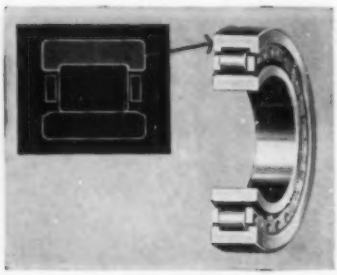
HYDRAULIC MOTORS, Constant Displacement Piston-type—Bulletin A-5205-A, 4 pp. General description of motor operation. With cutaway drawing, dimensional data and performance curves. Four new sizes for 36 motors are part of this line. Vickers, Inc., P.O. Box 302, Detroit 32.
Circle 44, inside back cover

PROTECTIVE COATING—Bulletin, 12 pp. Features, properties and characteristics of plastic protective coating formulated from silicones and epoxies. With a guide for economic selection of coating by analyzing coverage, surface life, surface preparation, drying time, loss of operating time and refinishing cycles. Mono-Seal Products, 44 Garden St., Everett 49, Mass.
Circle 45, inside back cover

MINIATURE RECTANGULAR POWER CONNECTORS—Brochure, 6 pp. Specs, diagrams and general information on Series-250 power connectors.
(Continued on page 127)



Loggers' "weight-lifter" tests bearing stamina!



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Two parallel shoulders made integral with the outer race, as shown in gray above, increase rigidity and durability—keep rollers in proper alignment. Precision-ground rollers and races give quieter, smoother operation.

Tossing around logs 6 feet in diameter like toothpicks is no job for a softie! This machine has to be *built* for it right from the start—*right down to the bearings.* And that goes, too, for the trucks which haul these back-breaking giants over the most rugged terrain. Bower tapered and straight roller bearings have been *engineered* for just such work as this—to last longer, perform better under any road or load condition. Painstaking quality control plus basic bearing design refinements—like those shown at left—have reduced Bower Bearing failure to a practical minimum. *Whatever* your product, if it uses bearings, specify Bower! There's a complete line of tapered, straight and journal roller bearings for every field of transportation and industry.

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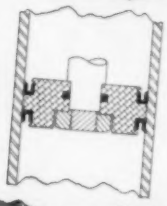

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New trend simplifies piston design... reduces machining costs... facilitates installation... reduces friction

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Rectangular design of Palmetto U-Rings increases stability and strength and eliminates rolling in groove. Rugged, with wide lip flare for use in cylinders made from commercial tubing honed up to .030 over nominal sizes. Same sizes available in synthetic or fabric construction permits interchangeability of packing in low or high pressure cylinders. ALLOWS STANDARDIZATION OF COMPONENT PARTS . . . INCREASES EFFICIENCY.

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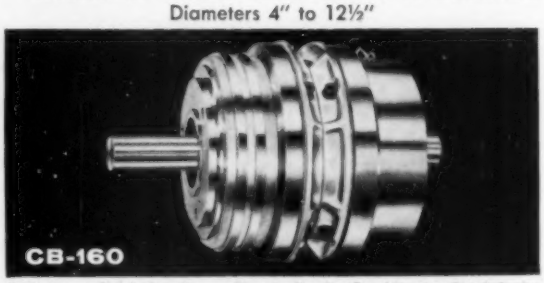
Diameters 4" to 12½"



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***Three* Ways Best for Automated Control**

1 Simple Design—exclusive diaphragm is only moving part, obsoletes conventional clutch or brake made up of numerous troublesome parts.

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Catalogs and Bulletins.....continued

DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 46, inside back cover

GERMANIUM COMPONENT RECTIFIERS—Bulletin GEA-5773C, 6 pp. Tells how to select and apply fan-cooled and blower-cooled germanium rectifiers. Tables, charts, line drawing and photos illustrate operation, operating characteristics, dimensions, ratings, and model numbers. General Electric Co., Schenectady 5, N. Y.

Circle 47, inside back cover

SPECIAL CAMS—Booklet SC-1, 8 pp. Describes service for providing cams of every type. Shows operating and manufacturing facilities and describes a few of the special cams designed and produced to meet aircraft, guided-missile, electronic and textile-industry specifications. American Cam Co., Inc., P.O. Box 2106, Hartford, Conn.

Circle 48, inside back cover

INDUSTRIAL-TYPE SELENIUM RECTIFIERS—Bulletin 248A, 6 pp. Ratings and dimensions for high-current density, industrial-type selenium rectifiers. Also, data on uprating the rectifiers when cooled by forced air. Radio Receptor Co., Inc., 240 Wythe Ave., Brooklyn 11, N. Y.

Circle 49, inside back cover

DOUBLE - ENVELOPING WORK GEARING — Brochure CD-200, 24 pp. Engineering formulas and step-by-step instructions for designing and applying this gearing to drives of all types. Service factors and lubrication information are included. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12.

Circle 50, inside back cover

ROTARY SEALS AND VALVES—Bulletin ML-177, 6 pp. Describes functions and applications. Has engineering and dimensional-data tables. Fawick Airflex Div., Fawick Corp., 9919 Clinton Rd., Cleveland 11.

Circle 51, inside back cover

AUTOMATION—Manual U1352, 196 pp. An aid to help management investigate the electronic computer, its capabilities, operation and applications. A study of data procession is followed by a listing of computer applications, and a survey of types of data processing systems. An introductory course of Univac programming fills five sections. Also included are techniques for sorting data, and common operational routines. Remington Rand Univac, 315 Fourth Ave., New York 10.

Circle 52, inside back cover

CONVERSION FACTORS—Wall chart. Reference table speeds up both common conversions—inches to centimeters, watts to horsepower, cubic feet to liters—and conversions difficult to find—microns to meters and quintal to lb for example. Precision Equipment Co., 4411 E. Ravenswood Ave., Chicago 40.

Circle 53, inside back cover

ROUND STEEL TUBING—Booklet, 14 pp. Carries weight tables and figures for tubing to 10¾-in. OD with wall thicknesses to 1¼ in. Data is applicable to welded or seamless steel tubing. Instructions for figuring weights for square and rectangular tubing are included. Revere Copper and Brass, Inc., Rome Mfg. Co. Div., P.O. Box 111, Rome, N. Y.

Circle 54, inside back cover

TRANSFER MATERIALS—Bulletin 132, 12 pp. Uses and processing techniques. For application in engineering blueprint and microfilm departments. Ampto, Inc., Newton, N. J.

Circle 55, inside back cover

PILOT CHECK VALVES — Catalog sheets 2.30, 2.315, 2.21, 2.225. Specs, engineering details and dimensional drawings on single and double pilot check valves with emergency manual release. Fluid Controls, Inc., 1284 N. Center St., Mentor, Ohio.

Circle 56, inside back cover

SEALED GEAR PUMP—Catalog sheet TR-57D, 2pp. Two models described. Internal mechanisms of both models are shown with labeled drawings. Data on discharge rates, speeds, shaft connections, valves and other characteristics are included. Bijur Lubricating Corp., 151 W. Passaic Ave., Rochelle Park, N. J.

Circle 57, inside back cover

MINIATURE MOTORIZED DEVICES—Catalog, 8 pp. Gives characteristics, specifications and dimensions of instrument panel vibrators, dc generators, planetary gear reductions, clutches, rate gyros, actuators, timers and power positioners. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4.

Circle 58, inside back cover

PIPE AND STRAIGHT THREAD SEALS—Bulletin, 8 pp. Advantages of these seals, together with application, installation, dimensional, price and weight data. Tru-Seal Div., Flick-Reedy Corp., 2040 N. Hawthorne Ave., Melrose Park, Ill.

Circle 59, inside back cover

COPPER-COATED STEEL WIRE — Bulletin 202, 8 pp. Properties, specs and applications are discussed. With curves, tables and photos. National-Standard Co., Niles, Mich.

Circle 60, inside back cover

MINIATURE INDICATOR LIGHTS — Brochure, 6 pp. Covers miniature indicator lights and special-function indicators for aircraft, computers, and industrial and lab instruments. A variety of data-readout and other indicators is shown. Includes photos, descriptions and dimensional drawings for the whole line. Eldema Corp., 1805 Belcroft Ave., El Monte, Calif.

Circle 61, inside back cover

ELECTRONIC COMPONENTS AND MOTORS—Catalog 43, 28 pp. Lists synchros, ac-dc motors, servo motors, inverters, actuators, gear motors, generators, and other components. Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N. J.

Circle 62, inside back cover

ELECTRONIC EQUIPMENT—Catalog, 8 pp. Information and operating data on meter calibrators, voltage regulators, digital readout meters, dc power supplies and other electronic equipment for lab or production use. Dept. PEN, Davenport Mfg. Co., 1713 N. Ashland Ave., Chicago 22.

Circle 63, inside back cover

ELAPSED TIME INDICATORS—Bulletin AWH ET-602, 2 pp. Describes subminiature hermetically sealed elapsed time indicators with 400 cps motors, for operation on 115 v. Illustrates two basic models and lists catalog part numbers along with specs and outline dimensions. A. W. Haydon Co., Waterbury, Conn.

Circle 64, inside back cover

MODULAR CABINETS — Catalog, 14 pp. Information and specifications on factory-assembled, panel control cabinets. With dimensional drawings, data and an explanation of the pricing system. Cleveland Fuel Equipment Co., 1111 Brookpark Rd., Cleveland 9.

Circle 65, inside back cover

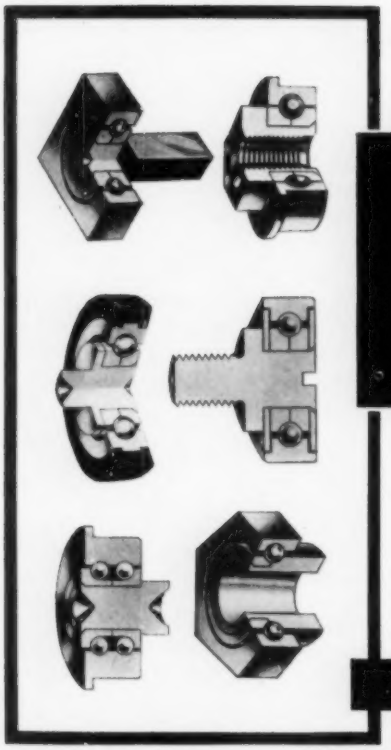
TERMINALS AND CONNECTORS — Catalog, 12 pp. Standard line of terminals, connectors, blades and attaching machines. Electric Terminal Corp., 75 Virginia Ave., Providence, R. I.

Circle 66, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

HOSE ASSEMBLIES—Handbook, 64 pp. Hard-cover book describes fluorocarbon flexible hose and hose assemblies for missile and aircraft industries. Gives engineering data, specs, and working drawings on the corrosion-resistant, chemically inert, high-temperature hose assemblies. With working suggestions and applications. Resistoflex Corp., Woodland Rd., Roseland, N. J.



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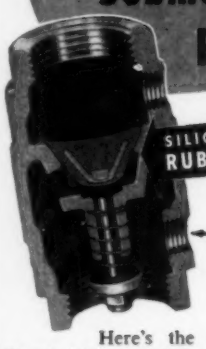
SPECIAL
CHECK VALVES FOR Submersible Pumps



Tapped one or two holes for attaching Pressure Switch, Pressure Gauge or Snifter Valve.

No. 350

Here's the answer to your Check Valve problems on submersible pumps. The taper-type rubber poppet is noiseless, can't leak, opens easily. Works in any position. All bronze body. Four sizes, 1" through 2". May be tapped for one or two side connections as shown. Used as original equipment by many leading pump manufacturers.

Write or telephone Harrison 3313 today for Bulletin No. 202.

STRATAFLO PRODUCTS, INC.
FORT WAYNE 1, INDIANA

Tangents...

Golden Rule

We enter this Christmas season with very mixed emotions, with the knowledge that the biblical precept of "Peace on earth . . ." is still in dire peril. All around us are wars and rumors of wars, brought closer by events of the past twelvemonth. Christmas is, of course, particularly a Christian holiday, with its deepest significance to the followers of Jesus Christ.

Particularly at this season, there are those who insist lasting peace can be achieved only by general adherence to the gospel of Christ. They cite the Golden Rule, "Do unto others as you would they should do unto you," as the theme of Christianity and the basic formula for better feeling between men and between nations.

It is true that this rule of reciprocity is the greatest ethic of any, because it is so all-embracing–but it can be traced back long before Christianity. It is actually the basic rule under which men live together, one that can be found in every civilization and in every one of the eleven religions that exist today. Here it is:

Buddhism—(*Religion of 520 million people of Asia. Established 600 B.C.*)
"Hurt not others with that which pains yourself."—*Udanavarga* 5.18

Christianity—(*Religion of 605 million people of Europe, Asia, America, Begun A.D. 30*)
"All things whatsoever ye would that men should do to you, do ye even so to them: for this is the law and the prophets." *St Matthew* 7.12

Confucianism—(*Religion of 400 million Chinese, Koreans and Manchurians. Established 600 B.C.*)
"Is there any one maxim which ought to be acted upon throughout one's whole life? Surely the maxim of loving-kindness is such—Do not unto others what you would not they should do unto you." *Analects* 15.23

Hebraism—(*Religion of 16 million Jews, half in Europe, a quarter in the U.S., others elsewhere (prewar figures). Founded 1300 B.C.*)
"What is hurtful to yourself do not to your fellow man. That is the whole of the Torah and the remainder is but commentary. Go learn it." *Talmud*

Hinduism—(*Religion of 300 million people, principally in southeastern Asia and Southern Africa. Established about 3000 B.C.*)
"This is the sum of duty: do naught to others which if done to thee, would cause thee pain." *Mahabharata* 5.1517

Islam—(*Religion of 300 million Mohammedans in Arabia, Africa and southern Europe. Est. A.D. 622*)
"No one of you is a believer until he loves for his brother what he loves for himself." *Traditions*

Jainism—(*Religion of 1.45 million East Indians. Prehistoric in origin*)
"In happiness and suffering, in joy and grief, we should regard all creatures as we regard our own self, and should therefore refrain from inflicting upon others such injury as would appear undesirable to us if inflicted upon ourselves." *Yogashastra* 2.20

Shinto—(*Religion of about 17 million Japanese. Prehistoric in origin*)
"Do not forget that the world is one great family." *Negative precept* 5

Sikhism—(*Religion of 5.7 million East Indians. Established 1500 A.D.*)
"As thou deemest thyself so deem others. Then shalt thou become a partner in heaven." *Kabir*

Taoism—(*Religion of an unknown number of Chinese, Koreans and Manchurians. Established 600 B.C.*)
"Regard your neighbor's gain as your own gain: and regard your neighbor's loss as your own loss." *T'ai Shang Kan Ying P'ien*

Zoroastrianism—(*Religion of 125,000 East Indians and Persians. Established 600B.C.*)
"That nature only is good when it shall not do unto another whatever is not good for its own self." *Dadistan-i-dinik* 94.5

So we see that Christianity is not alone in advocating the Golden Rule; it is fundamental in the hearts of all people everywhere. Our effort in the days to be thus should not be to force others to think as we think, but to realize that each of us, regardless of creed, must do more than repeat the Golden Rule. We must practice it.

Then, and then only can we achieve "peace on earth among men of good will."

—EJT

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DESIGN ABSTRACTS

Curve Fitting

Systematic approaches to fitting of numerical data gathered from tests, surveys or observations based on arithmetic and geometry are discussed. Reasons for choosing between straightline, exponential, hyperbolic curves and procedures for application to data are given. Types of equations discussed are typical of others for which parabolic and logarithmic curves would be used.

Abstracted from "Curve Fitting," by T. R. Hoffman, Allis-Chalmers Electrical Review, 3rd Quarter 1957, Milwaukee 1.

ABC Conference on Drafting Practice

This latest in the series of conferences between American, British and Canadian delegations to set up common standards in drafting practices was held in Toronto in September. Already, as a result of this group's work, screw threads in the three countries are almost entirely interchangeable. This group of articles describing some of the proceedings include following titles: Area of Agreement and Disagreement in Drawing Standards of USA, UK and Canada; True Positions on Drawings; Maximum Material Condition on Drawings; Geometric Forms.

Abstracted from Magazine of Standards, Nov. 1957, ASA, Inc., 70 E. 45 St., New York 17.

What's in The Literature

The vice-president for research of one of this country's large corporations is quoted as saying, "If a research job costs less than $100,000 it is cheaper for us to do it than to find out if it has been done before and is reported in the literature." The author contrasts this with the situation 20 to 25 years ago, when a steel company could assign a new staff member at $200 a month to a literature-searching problem. Ten days to a month later, at a cost not exceeding $200-300, a complete summary could be expected.

The change is reported to be a result of the increase in output of technical literature (the Engineering Index prepared 27,000 abstracts in 1956 alone), lack of technical manpower, distaste for this kind of work, and increased salaries of such personnel. A three-pronged attack is proposed: development of uniform indexing system based on scientific principles, classification system permitting rapid coding, a machine-based system of locating and retrieving coded references. Brief descriptions of ASM's activities along these lines is given.

Abstracted from "What's in The Literature?" by Frank T. Sisco, Engineering Foundation, Metal Progress, Oct. 1957, 7301 Euclid Ave., Cleveland 3.

Limited End-Float Couplings

Types of equipment in which unlimited end-float of coupled shafts can cause bearing damage are described, together with causes. Available limited couplings are analyzed and application to various equipment discussed.

Abstracted from "Solve Axial Thrust Problems with Limited End-float Couplings," by E. B. Mills and J. E. Peterman, Allis-Chalmers Electrical Review, Third quarter 1957, Milwaukee 1.

Ac Equipment for Variable-Speed Drives

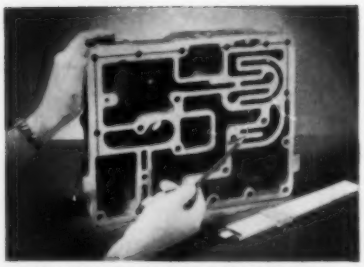
Advantages of these induction-frequency converter systems are given and methods of application to various types of drives are discussed. Power to and from converter shaft is plotted. Methods of providing feedback control are describd.

Abstracted from "Variable Speed Drives Using Ac Equipment," by Harlan S. Neuville, Allis-Chalmers Electrical Review, Third quarter 1957, Milwaukee 1.

Directionally Reinforced Plastics

This article, the first of a series, discusses typical applications of directionally reinforced plastics, composed of oriented filaments in a plastic compound. Mechanical properties and the factors governing them are discussed, and tables and curves are included.

Abstracted from "Design and Fabrication with Directionally Reinforced Plastics," by A. C. Donaldson and R. B. Velleu, Minnesota Mining and Mfg. Co., Modern Plastics, Oct. 1957, 575 Madison Ave., New York 22.



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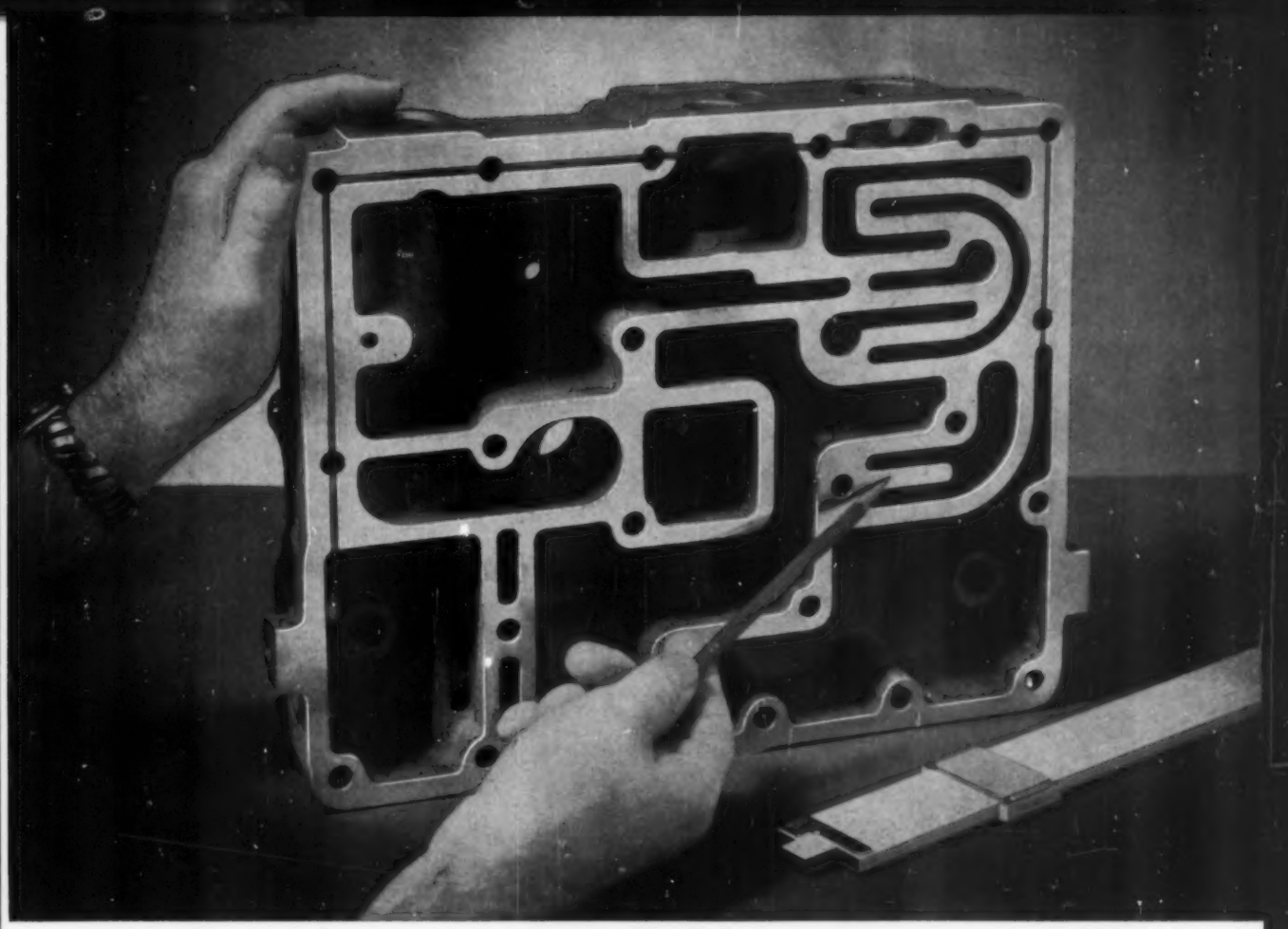

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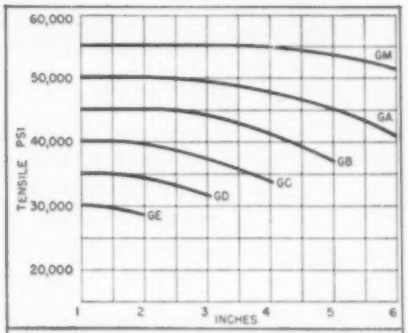

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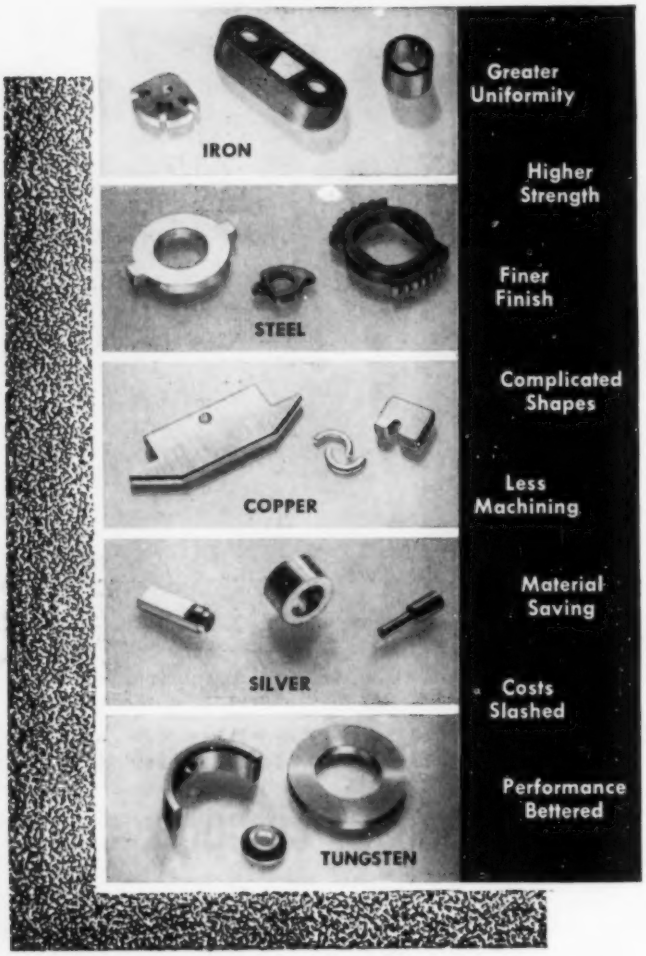

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Design of Linear Feedback Controls

GEORGE C. NEWTON, JR., LEONARD A. GOULD and JAMES F. KAISER, *Massachusetts Institute of Technology*, 6¼ x 9¼ *in.*, 419 *pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York* 16. $12.

In this book the approach to control-systems design is based on applying the methods of mathematical analysis to idealized models, which represent physical equipment. Taking as their starting point the system specifications, the authors include descriptions of the input, the disturbances, and the desired response. A statement of the basis on which the system performance will be judged is also included; this is in the form of a performance index. The design objective is to minimize (or maximize) the chosen performance index. Analytical design theory as given here is a presentation of the ways to reach this objective.

Included is a comprehensive discussion of the analytical design procedure for two performance indices. For systems subject to transient input signals, the integral-square error is used as a peformance index. For stochastic input signals, on the other hand, the mean-square error is used. Appendices are included.

Air Conditioning

WILLIS R. WOOLRICH, *Univ. of Texas, and* WILLIS R. WOOLRICH, JR., 6 x 9 *in.*, 384 *pp. Published by The Ronald Press Co., 15 E. 26th St., New York* 10. $7.50.

This textbook, designed for the use of engineering students, professional engineers and architects, is organized into four parts. Part I is devoted to the general thermodynamics of air conditioning and to problems of system-load determination and design including: basic thermodynamics and the thermodynamics of gas-vapor mixtures; development of the psychrometric chart and psychchrometric processes; basic physiological facts upon which air-conditioning design necessarily de-

(Continued on page 133)

pends; heat transfer, with considerable emphasis placed on cooling by night radiation and on the influence of structural mass in establishing either greater or less "livability" through transient diurnal effects; load evaluation for heating, and for cooling.

Part II consists of chapters on fuels and combustion involving boilers, radiators and convectors; steam, hot water, warm air, and radiant panel heating systems. Part III covers types of refrigeration, including cooling by iced air and by evaporation. Part IV deals with piping design, air distribution, automatic control and instrumentation, sound control and air contaminant control.

Documentation and Information Retrieval

J. W. PERRY and ALLEN KENT, 6 x 9 in., 156 pp. *Published by Interscience Publishers, Inc., 250 Fifth Ave., New York 1.* $5.

During recent years, professional men in various fields have been confronted with problems in making efficient use of recorded knowledge. In science and technology, for example, publication rates have maintained a record-breaking pace, particularly since the conclusion of World War II. The practical necessity of coping with information problems has resulted in much time and effort devoted to developing new methods and techniques. This book discusses the mathematical formulation of basic principles, together with cost analysis of procedures and operations leading to the development of information systems on a firm engineering basis.

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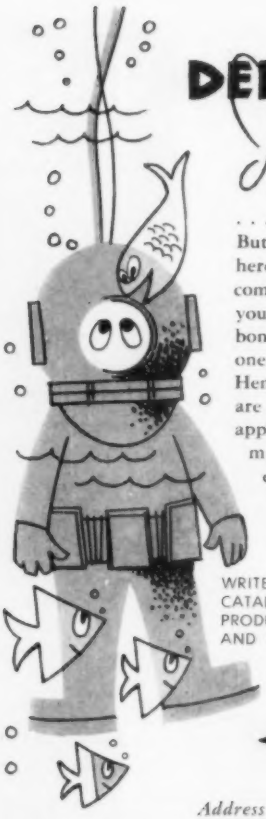

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Rebuttal to Mr. Amann on the "Salary Problem"

To the Editor:

This concerns a letter to you from Mr. Joseph Amann (Nov. 25, p. 189) of the Engineers and Scientists of America, regarding my letter on "The Salary Problem."

Mr. Amann apparently has concluded that my letter (Oct. 14, p. 195) favored keeping engineers in ignorance of salaries so that management can work quietly to the engineers' detriment. I am truly surprised that he could have drawn such an erroneous conclusion. Also, he is apparently unaware that the day of such unwise management practices is long since past.

Today's modern company, dependent upon research and development for its future existence, cannot possibly hope to maintain a satisfactory competitive position by such policies. Instead, all those companies which come within my own experience have diligently worked to maintain their salary structures up-to-date and in keeping with the national and local picture, to the end that an engineer can have the utmost confidence in the company's fairness.

Now, as to the salary differentials mentioned by Mr. Amann, it seems to me that there are only two real reasons for considerable differentials. These are: (1) years of experience; (2) level of responsibility. It certainly should be possible for an exceptional man to be promoted rapidly to higher levels of responsibility, and thus gain greater rewards. But for men of similar levels of responsibility and experience, any salary differentials should be minor, or entirely nonexistent. Even though everyone knows that salaries are things not to be discussed, knowledge of nonjustifiable differentials always seems to come out, and is certain to cause lack of confidence.

Another point which Mr. Amann

(Continued on page 137)

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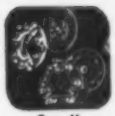
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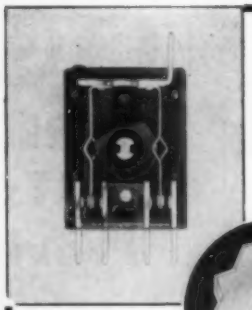

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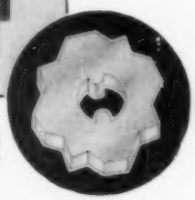

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apparently fails to understand is that engineers themselves are members of the management team. In independent and responsible action, an engineer daily makes decisions which influence his company's future. These decisions must be extracted from a continual welter of conflicting data, and be resolved to the common company good. Surely this is in the highest tradition of professional endeavor, and flourishes best in an atmosphere of mutual trust.

Again I underscore my original point. In the mind of the engineer studying a national salary survey, there is always the question, "Where do I fit?" And there is no real way for him to know. He certainly sees that some people of his age bracket make far more than he does, and cannot possibly know how that man relates to him in degree of job responsibility.

Such a man may be managing a thousand people, for all he can tell. Hence, unless some practical way can be found to express all the facts, and gain the "complete understanding" Mr. Amann refers to, we are better off without publishing such surveys.

—JOHN D. KEMPER
Asst. to vice-president—Engineering
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Dash, not Dot Makes Big Difference

To the Editor:

That was excellent editorial treatment PRODUCT ENGINEERING gave us in the Nov. 18 issue on our new bellows-type flowmeter. Unfortunately, an error crept in which our engineering department considers somewhat serious. In rewriting our story, you state that the flowmeter is available in 15 ranges from 0.20 to 0.400 in., using a decimal point where one was not used originally. (The ranges should read 0 to 20 in.; to 0 to 400 in.) It is easy to understand how such things happen, but if this can be corrected, it would be greatly appreciated. Also, in referring readers to the address, it should be Brown Instruments Div., Wayne & Windrim Aves., Philadelphia 44, Penna. —GEORGE STAUTER
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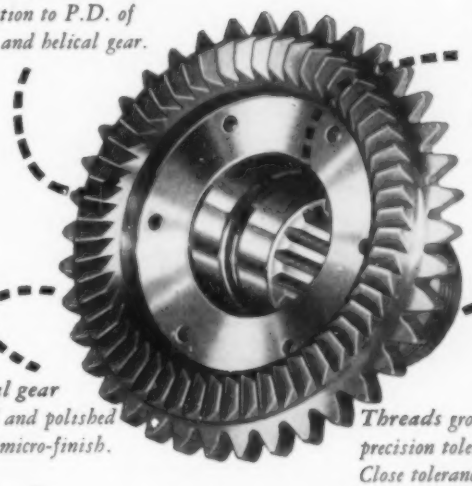

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F. J. Stokes Corp., Philadelphia, has formally opened its new $80,000-powder-metal-research-and-development lab. It provides the company with larger and more comprehensive facilities for improving powder-metallurgy techniques and widening their use in industry. The lab is equipped with a full range of standard production-type powder-metal presses, with operating pressures running from 4 to 200 ton, as well as mixing and blending equipment, a controlled-atmosphere sintering furnace, and complete equipment for testing the metallurgical properties of finished powder-metal parts. It it staffed by fulltime experienced powder-metal specialists.

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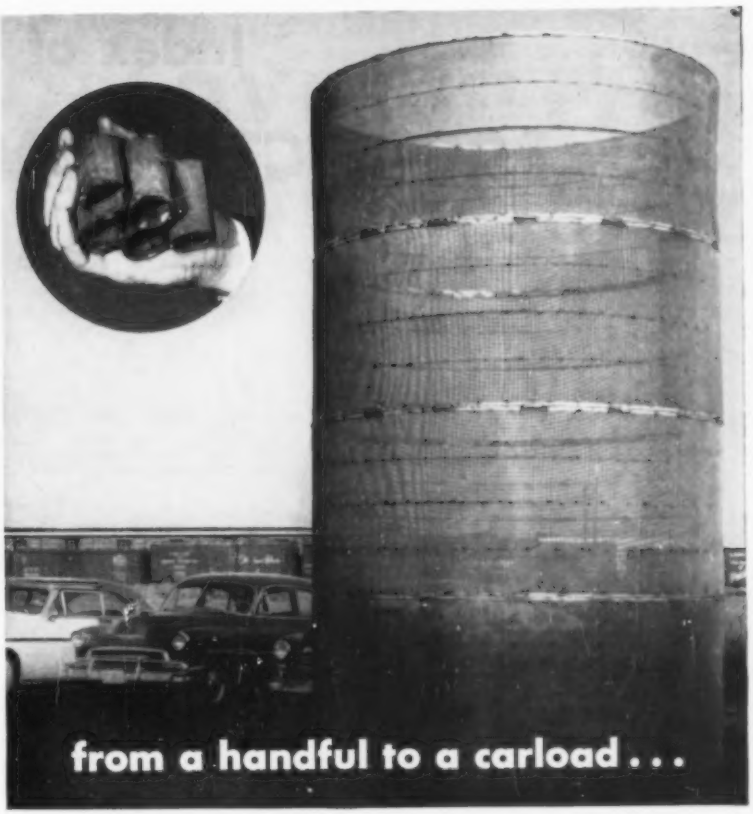

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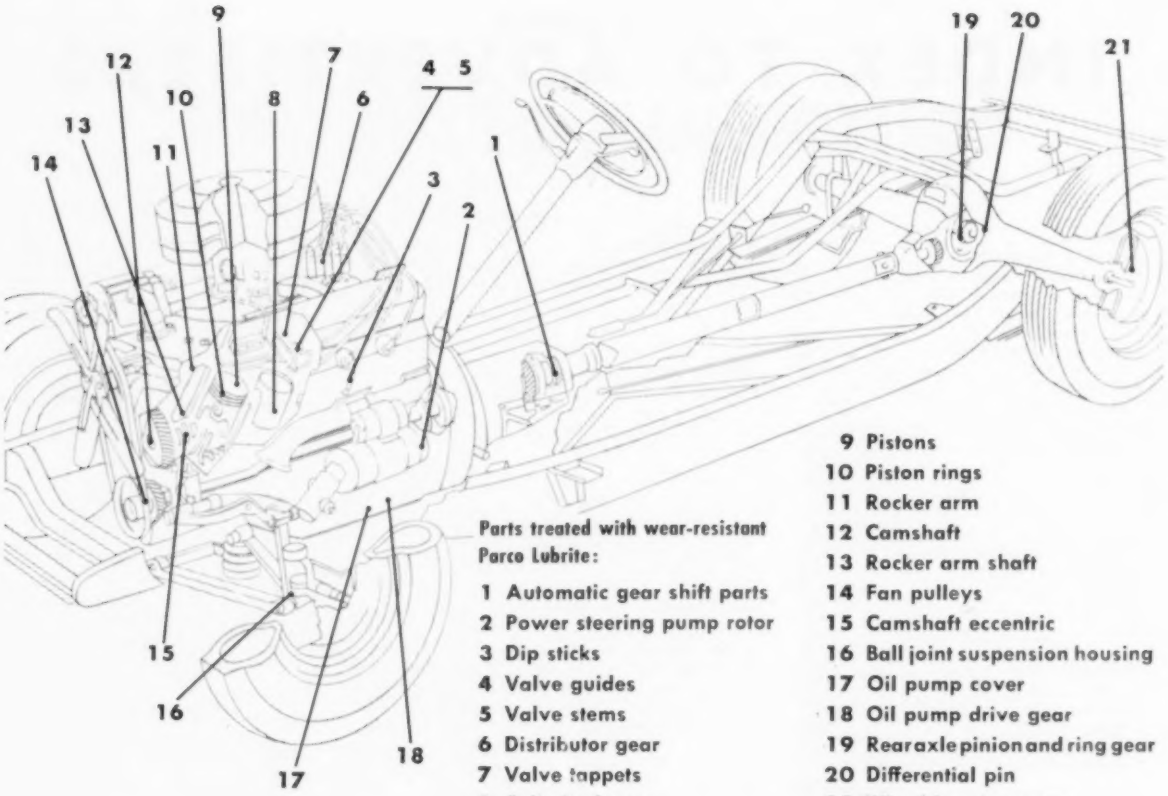

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25—High-speed Lightweight Diesel
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27—Sensor Unit
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31—Phantom-ruled Vellum
32—Electronic Cables
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54—Round Steel Tubing, 14 pp. Rome Mfg. Co.

55—Transfer Materials, 12 pp. Ampto.

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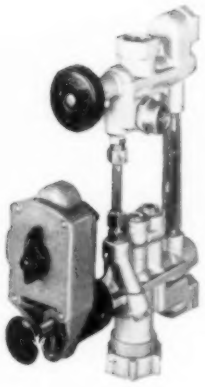

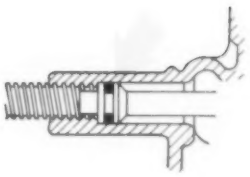

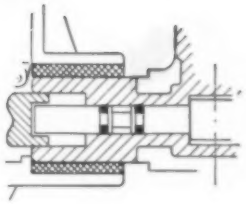

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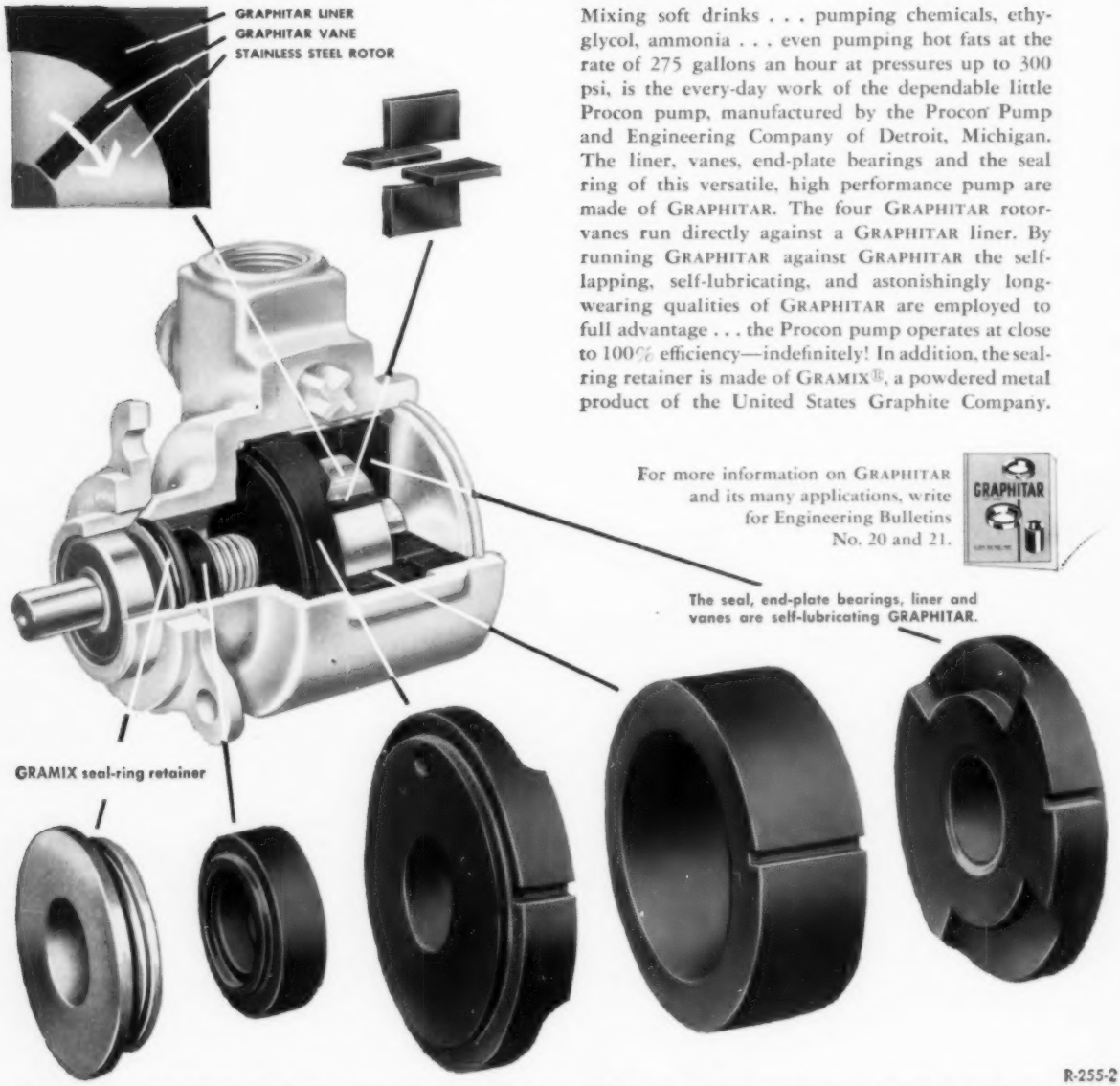
GRAPHITAR LINER
GRAPHITAR VANE
STAINLESS STEEL ROTOR
GRAMIX seal-ring retainer
The seal, end-plate bearings, liner and vanes are self-lubricating GRAPHITAR.

Mixing soft drinks . . . pumping chemicals, ethyglycol, ammonia . . . even pumping hot fats at the rate of 275 gallons an hour at pressures up to 300 psi, is the every-day work of the dependable little Procon pump, manufactured by the Procon Pump and Engineering Company of Detroit, Michigan. The liner, vanes, end-plate bearings and the seal ring of this versatile, high performance pump are made of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against a GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR the self-lapping, self-lubricating, and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage . . . the Procon pump operates at close to 100% efficiency—indefinitely! In addition, the seal-ring retainer is made of GRAMIX®, a powdered metal product of the United States Graphite Company.

For more information on GRAPHITAR and its many applications, write for Engineering Bulletins No. 20 and 21.

R-255-2

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

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